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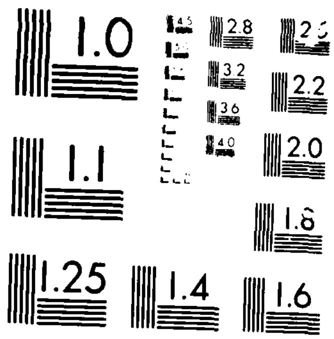
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AIR WEAPON SYSTEMS IN THE THIRD WORLD:
A COMBAT POTENTIAL ASSESSMENT TECHNIQUE

Christopher L. Christon
Lieutenant Colonel, USAF

June 1986

Naval Postgraduate School
Monterey, California

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This report, prepared under the auspices of the Director of Central Intelligence's Exceptional Intelligence Analyst Program, proposes a quantitative technique for assessing the impact of air weapons systems' transfers on the combat potential of Middle Eastern recipients. Existing quantitative methodologies are examined to identify strengths and weaknesses. An analytical paradigm is outlined, and essential measurement variables isolated. Data collection and estimation techniques are explained. A data reduction scheme based on an amalgam of factor analysis and multi-attribute utility techniques

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is described and tested. A linear aggregational technique which combines the relative contributions of air weapons attributes and subsystems in four mission roles (air defense, fighter/air superiority, interdiction, close air support) is developed and applied to 125 operational and programmed aircraft. Current and projected combat aircraft inventories for 22 Middle Eastern/North African nations are established, and force propagation potential (sortie production) is estimated for each aircraft. Sortie production and air weapon system combat potential assessments are combined to generate national force air combat potential estimates in four mission areas for the period 1984 through 1990. An example illustrating the proposed methodology's flexibility in responding to differing alternatives and assumptions in support of arms transfer policy making is offered. Detailed listings of raw study data, aircraft combat potential estimates, inventories, and national force air combat potential are included. The study concludes that the proposed methodology is more comprehensive and sensitive to user demands than existing systems and warrants further evolution.

AIR WEAPON SYSTEMS IN THE THIRD WORLD
A COMBAT POTENTIAL ASSESSMENT TECHNIQUE

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June 1986

EXECUTIVE SUMMARY

Security assistance to the Third World will remain a vibrant topic in the American political dialogue for the foreseeable future. While specific issues are fraught with political, economic, ethical, and emotional overtones, analysis of the military dimension is inseparable from the decision making process. The military analyst's charter is to provide decision makers with comprehensive assessments of arms transfer alternatives, probing their contributions to recipient force structure modernization and forecasting their impacts on regional military stability.

In this pursuit, some form of quantitative analysis is inescapable, be it as simple as the tabulation of military inventories or as complex as a sophisticated war gaming model. No matter the complexity of the technique employed, its processes must be transparent to the decision maker and its content malleable to his priorites and perceptions. At the same time, the technique must be slaved to the objectives and components of the analytical question, not vice versa. To assist arms transfer policy making, the assessment of potential capabilities to conduct definable operations in a specific environment is vital. To do less is to leave critical stones unturned.

Simple tabular techniques have a place in the panoply of military analysis, but their results can rarely be translated into militarily relevant conclusions. The systematized aggregation of performance and force propagation characteristics is an elemental attribute of any model which purports to assess combat capabilities. The objective of this research effort has been to develop a methodology which captures these facets and aggregates them according to their relative utilities in generating potential combat outputs.

Using air weapon systems (125 aircraft) and the Middle East/North African region (22 countries) as a developmental test bed, the study began by evaluating the assets and liabilities of earlier aggregational methodologies. Factor analysis stood out because of its ability to consolidate multiple variables into common attribute performance measures. However, its combinational logic is haphazard when applied at the weapon system level, and its output measures are not legitimate candidates for aggregation at the force level. Multi-attribute utility technique produces a judgment based combinational matrix but is administratively unwieldly and naturally applicable only to ratio level data. The weighted linear aggregation technique developed by The Analytic Sciences Corporation incorporates expert judgment and processes data of any measurement level but cannot accommodate multi-variable attributes and is insensitive to performance variations within broadly defined subsystem categories. Whatever its strengths or weaknesses, each methodology demonstrated the criticality of solid and comprehensive data input to the production of meaningful results.

To guide the data collection process, a matrix was developed the key elements of which constitute the components implicated in assessing force air combat capability. Two essential elements, air weapon system performance and force propagation potential, were positioned at the apex of the framework. They were divided into the subcomponents which define their basic dimensions. Along with the various categories of subsystem, the air weapon system performance group included a family of factors which relate the subsystems in terms of configuration and combat utility. On the force propagation side of the ledger, inventory, mission allocation, and sortie generation subcomponents were identified. The importance of intangible factors such as operator proficiency and C^3I support was acknowledged, but their consideration deferred to other research efforts. Each subcomponent thus identified was further divided into the performance attributes which contribute to its operation. These were in turn subdivided into the variables which describe those attributes.

Data collection was accomplished using open source data. Certain artifical constraints were established to expedite the process. Only fixed wing aircraft with direct combat application in recent or future Middle Eastern combat scenarios were considered. When data were unavailable, they were estimated using the most accurate technique which could be supported. In some instances, specific data values are consequently open to challenge. While the possible inaccuracies are lamentable, they are not fatal to the evaluation technique itself and can easily be revised in subsequent applications. Since the methodology aimed to support the development of future arms transfer policies, national air combat inventories were anchored with known data from the past two years and projected out to 1990. A unique data set was collected to determine the relative utilities of attributes and subsystems in definable combat roles. A panel of 25 fighter experts familiar with Middle Eastern air operations was polled to ascertain their views on the relationships which obtain among attributes and subsystems in four different mission areas. The results were synthesized statistically and recast as relational variable values to be employed during the weapon system combinational phase.

Only after an analytical structure had been articulated and supporting data collected was a data reduction scheme devised, reversing the process followed in some other research efforts. Factor analysis was employed to create relative index values for attributes described by multiple variables. Targeted at the attribute level, this minimalist version of the factor analysis methodology purged the indices of extraneous variable influences. Ratio properties were restored to the indices through the utilization of a zero-valued control case the factor score for which constituted a threshold from which other scores in the data set could be scaled. Variables described by nominal values were not included in the factor problems to preclude their distorting influences but were reserved for introduction in the aggregation process.

The computational phase itself was adapted with a few major variations from the linear equations developed by The Analytic Sciences Corporation. The process was initiated at the bottom of the analytical ladder, combining subsystem attributes. Expert assigned values for nominally described variables were used to modify the raw attribute scores extracted from the data reduction phase. Attribute scores were combined in accordance with their relative air combat utilities in each mission area. An analogous procedure was followed at the subcomponent and component levels, with the computations not only considering relative utility values but also conforming to specific air weapon system configurations. The product is a set of relative combat potential scores (Air Combat Potential Units) for each of the 125 air weapon systems in whatever mission roles were appropriate.

Force propagation values were computed in a somewhat different fashion. National aircraft inventories, mission allocations, operational availability rates, maintenance requirements, and maintenance resources were considered in a series of equations which computed the sortie generation potential for each possessed air weapon system in those roles to which it would likely be committed. To illustrate the impact of personnel force quality on sortie generation, an additional force level factor, the relative support index, was also injected into select force propagation equations. Since the variables on which the support index was predicated are considered 'soft' surrogates for personnel quality, its general application is not recommended. However, its profound influence testifies to the requirement for such intangibles to be considered objectively or subjectively in force propagation and air combat analysis. In the ultimate computational step, air weapon system mission potential and national force propagation potential were mated to produce an estimate of a country's air combat potential in four mission roles on a single day of flying.

The results of the aggregation phase were reviewed to determine their efficacy both at the air weapon system and national force levels. The results conformed to intuitive assessments and poignantly demonstrated the desirability of employing a analytical scheme which aggregated the cumulative effects of system and force subcomponents on specific mission outputs. To further exercise the model, a phased analysis of a specific arms transfer proposal (advanced air defense fighters for Jordan) was conducted. The model showed itself to be responsive to the type of modifications a decision maker might stipulate in evaluating specific weapon system alternatives, gauging their contribution to force capabilities under varying conditions, and analyzing their impact on regional military balances under differing conflict scenarios.

The air combat potential aggregation methodology proposed in this study is a powerful and flexible mechanism with which to analyze the composition, benefits, and liabilities of air weapon systems individually and at the force and regional levels. Its underlying philosophy, analytical framework, and combinational scheme are extendable to other regions, categories of weapons, and analytical problems. But the present model has its drawbacks. Solely relying on unclassified data sources, values for some critical vari-

ables had to be estimated. Consequent inaccuracies were inevitable. The linear combinational form used to aggregate values at each step in the process fails to capture the synergy among subcomponents, particularly in force level calculations. Unquestionably vital factors such as operator proficiency, C^3I support, and the ground air defense environment were not considered in the prototype. These elements need to be introduced in a fully proficient model or considered in modifying its results. Finally, the prototype as currently configured is not amenable to 'user-friendly' micro-computer processing. Creation of a responsive micro-based system is eminently feasible but requires additional developmental effort.

Each of these liabilities is surmountable and represents fertile ground for additional effort within the intelligence community. Utilizing the methodoligical framework and procedures, a classified data base could be easily created and expanded to include additional aircraft, subsytems, and regions. Analytical subsets addressing elements of the ground air defense environment could also be introduced into the model relatively painlessly. Of greater complexity is the development of algorithms which capture the synergy among system and force components. One possibility is to attempt adaptation of existing air combat simulations to define an alternative non-linear aggregational scheme. Integration of combat relevant intangibles is a similarly complex challenge. Reliable mathmatical representations might not prove possible, but the influences of operator proficiency and the like can be reasonably assessed by weapon system and regional experts and applied subjectively in interpreting model output.

The air weapon system potential model is not a predictor of combat outcomes, but it does provide the decision maker with finely textured and responsive static indicators of individual weapon system and force potential. These indicators are essential points of departure in evaluating the military dimension of security assistance options. With the enhancements described above, the methodology developed in this research effort represents a productive vehicle for intelligence community participation in the security assistance policy development process.

PREFACE

This technical note was prepared under the auspices of the Director of Central Intelligence's Exceptional Intelligence Analyst Program. It was originally conceived as a wide-gauged historical treatment of arms transfers to the Persian Gulf Southwest Asian region, the findings of which could serve as a base for future forecasting. From the outset, it was recognized that the essential cog in the analytical wheel was the methodology which portrayed the effects of military equipment transfers on recipient combat capabilities and regional stability. It had been assumed that existing analytical methodologies would be sufficient to the task.

That assumption proved fallacious and caused a reorientation in study objectives. Development of a model to index and aggregate combat potential became the focal point of the research effort. Owing to a variety of factors, not the least of which was my own limited expertise, the field of study was further narrowed to air weapon systems. The temporal emphasis also changed as the study evolved. The development of a responsive mechanism to support future decision making emerged as a more compelling challenge than charting the historical evolution of Middle Eastern air combat capabilities.

The resultant methodological scheme, detailed in this technical report, does not meet all of the goals originally set out for it. Most significantly, the political dimension of United States' arms transfer policy toward the Middle East is not addressed; nor are the economic and security advantages and liabilities inherent in the process considered. These omissions notwithstanding, the proposed methodology delves much more deeply into the intricacies of air combat potential assessment than had been originally contemplated and than is available in current assessment systems. I trust this benefit will compensate for the aforementioned analytical lapses.

Readers will note the methodology is cast as a policy assistance model, and most of the discussions revolve around its viability in that role. While some might consequently question its pertinence as an intelligence tool, my long-standing conviction is that policy development and intelligence analysis are inextricably meshed. In that light, the proposed methodology constitutes one among many tools which intelligence analysts can employ in assisting arms transfer decision makers. As an air intelligence analyst myself, I also believe the methodological structure, if not its content, can be profitably applied by colleagues assessing a variety of air threats and developments.

I would like to express my warmest thanks to the Intelligence Community Staff for funding the project, to the Assistant Chief of Staff Intelligence, HQ USAF, for allowing me the opportunity to pursue

it, and to the Naval Postgraduate School for providing a most hospitable research venue. Special personal thanks are due Dr. Edward Laurance of the Department of National Security Affairs who initially inspired the project and channelled its course; to Colonel Jack L. Houlgate, HQ USAF, Directorate of Estimates, who served as a most understanding and efficient project manager; to Lieutenant Colonel Richard Forney of the Department of National Security Affairs who provided consistent technical and moral support; to Colonel John Garrison whose counsel on arms transfer issues and practices was invaluable; and to Colonel Michael (Nort) Nelson who served as my mentor in sorting through and consolidating air weapon system performance attributes. Several non-government entities also helped me over rough spots in the research and were particularly gracious in sharing perceptions and methodological concepts. These include Mr. J. E. Gibson and his staff at the Northrop Corporation, Mr. William Vogt of The Analytic Sciences Corporation, and Dr. Ronald Sherwin and Ms. Joyce Mullen of Third Point Systems Corporation.

Despite the profound impact these individuals and many like them have had on the conceptualization and preparation of this report, I have undoubtedly included some misperceptions or technical errors in the final version. These are my responsibility alone.

The views expressed in this report are those of the author and do not represent the official position of the Naval Postgraduate School, the United States Air Force, the Department of Defense, the Intelligence Community Staff, or the United States Government.

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Chapter 1
ARMS TO THE THIRD WORLD

1.1 Introduction

Arms sales are far more than an economic occurrence, a military relationship, or an arms control challenge - arms sales are foreign policy writ large. - Andrew J. Pierre in *The Global Politics of Arms Sales.*

1.1.1 The Dynamics of International Arms Trade

Few who read a newspaper or watch the evening news would contradict this observation. Arms sales or grants have become the linchpin of American security relationships with much of the Third World. They are the cement which holds the Camp David Accords together; they are the nose under the Middle Eastern oil producers' tent; and they are on the leading edge of efforts to blunt direct or indirect Soviet advances in the Third World. Arms sales have been pivotal in enticing Third World governments to switch superpower allegiances and in securing overseas facilities to support force projection requirements. Important to United States' international security policy, arms transfers are critical, in the absence of comparable economic ailures, to Moscow's overtures to current or potential Third World allies. Most industrial nations, confronted with ever rising weapons system and imported energy costs, rely on large scale arms exports to maintain affordable economies of scale for their own indigenous weapons production.[1]

With the post-colonial diffusion of international power and the subsequent tattering of Cold War alliances, the Third World's demand for increasing quantities of high quality weapons has more than kept pace with the supply. Recognizing superpower reluctance to chance a direct confrontation over Third World conflicts, emerging regional powers have come to rely on weapons inventories rather than diplomatic assurances as the best guarantees of their own security.[2] Threats to the security in the non-industrial world have mushroomed in the past forty years, further stimulating demand. By one estimate, three-quarters of the conflicts occurring since World War Two have taken place in the Third World, with inter and intra state wars producing over 15 million casualties. With the post-war profusion of new states, the potential causes of war have multiplied. The aggregate number of national frontiers to be contested

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1 For instance, Cahn and Kruzel observe that military exports are vital to sustaining British and French military production lines, with aerospace industries required to export at least half their production to remain afloat. See Cahn et al, *Controlling Future Arms Trade*, pp.68-69.

2 See Pierre, *The Global Politics of Arms Sales*, pp. 275-280, for a thorough discussion of the current significance of arms transfers in international affairs.

has increased geometrically, as have the other sources of inter and intra-state conflict.[3] The genesis of the conflicts themselves is imbedded in a crosshatched web of intraregional rivalries, political instability, and ethnic hostilities and not in the availability of modern arms. Nonetheless, virtually all conflicts in the Third World have been fought with weapons supplied by the industrial nations.

It is open to debate if the availability of modern weapons stimulates or suppresses the tendency to violent conflict resolution in the Third World. Indeed, compelling historical and theoretical arguments can be made on either side of the question. The timely transfer of arms to a threatened state can make war an unacceptably costly option for an aggressive neighbor. Conversely, a perceived arms buildup by a potential adversary can provoke a preemptive attack (e.g., Israel in 1967). Modern weapons systems possess range, mobility, and firepower attributes which magnify the lethality of combat once joined, but those same characteristics might also foreshorten its duration. Rarely do weapon systems alone dictate the outcome of Third World conflict. Long term results are more often the product of intangibles such as military morale, national cohesion and will, and combat strategy. This fact notwithstanding, the acquisition of modern weapons is a preoccupying security concern of Third World leaders, and their unfettered supply is the litmus test of patron constancy. For major arms suppliers, responding to Third World demands poses a devilish political, military, economic, and ethical dilemma.

1.1.2 The American Dilemma

The American body politic has long sought to harmonize the elements in the arms transfer quandary. The tenor of arms transfer policies in the Twentieth Century has run the gamut from virtually unbridled promotion to high-minded prohibition. In the mildly pacifistic and isolationist climate of the 1930's, the United States Senate's Nye Committee investigated international arms trade and drafted legislation (Neutrality Act of 1935), which set up a governmental agency to control the sale of arms and required the President to apply an arms embargo against any countries involved in conflict. Spurred by the results of the Nye investigation and popular exposes such as Engelbrecht and Hanighen's *The Merchants of Death*, the British Labor Party spearheaded an eventually unsuccessful attempt to prohibit the private production and sale of arms by companies in the United Kingdom.[4]

Following World War II, the United States, France, and Great Britain undertook to forestall a weapons explosion in the Middle East through the formation of the Near Eastern Arms Coordinating Committee (1950), which was charged with implementing multi-lateral standards of restraint adopted in the Tripartite Agreement of the same year. The Committee was moderately successful in maintaining a quantitative balance in the flow of arms to Egypt, Israel, and Iraq, but became unworkable in 1955, when

[3] See Starr and Most, 'Patterns of Conflict', pp.39-48 for additional conflict related data.

[4] A fast-paced account of early Twentieth Century attempts to curtail international arms traffic can be found in Sampson, *The Arms Bazaar*, pp.68-89.

the Soviet Union entered the regional arms market.[5]

In a different political clime, the Nixon Administration viewed large scale arms transfers as a cost-effective vehicle for strengthening international political allies, creating surrogates whose military capabilities would preclude the requirement for direct American presence in unstable regions.[6] Reacting negatively to the 'Nixon Doctrine', Congress attached the Nelson Ammendment to the 1974 Military Assistance Bill mandating Congressional notification and review of proposed arms packages in excess of $25 million. A more restrictive approach was adopted in the International Security and Arms Export Control Act passed in June 1976. It not only reaffirmed Congressional review but prohibited strictly commercial sales in excess of $25 million and proposed that annual aggregate sales should not exceed the dollar level reached in 1976. 'Arms controllers' on Capitol Hill had an enthusiastic ally in President Carter whose political and ethical sensibilities had prompted him to include the control of arms transfers as a plank in his campaign platform. The policy which he promulgated set quantitative and qualitative boundaries to the export of arms. He proposed a descending dollar limit on agggregate transfers, a prohibition of the insertion of new or significantly higher combat capabilities into a region, and a number of other measures which would have severely curtailed the role of the American government and arms producers in stimulating or responding to Third World demand for arms.

The tenor of the Reagan Administration's arms transfer policy has been more aggressive, substituting, to paraphrase James Buckley, 'a healthy sense of self preservation' for 'theology'.[7] Intent and rhetoric aside, arms sales since 1981 have still been scrutinized and reigned in by a Congress suspicious of the efficacy of arms transfers and sensitive to domestic political pressures. With the exception of transfers to Israel and Egypt in compensation for the maintenance of the Camp David Agreement, no major arms sale has been approved without a lengthy, public, and at times vitriolic debate. The furor over the AWACS sale to Saudi Arabia was without equal in post-war history. Congressional opposition forced the Administration to defer plans to upgrade Jordan's air defense capabilities and to abandon a program to further enhance Saudi Arabian air defense and ground attack capabilities. Most recently, a proposal to supply air-to-air missiles for fighters the Saudi's had purchased from the United States was the subject of fierce political controversy.

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5 See Kemp, 'Arms & Security', pp.19-20; and Sherwood, *The Out of Area Debate*.

6 The program to establish Iran and Saudi Arabia as the 'twin pillars' of security in the Persian Gulf after the withdrawal of British forces in 1970 stands as a case in point.

7 Quoted in Pierre, op.cit., p.62.

1.1.3 To Trade or Not To Trade

While U.S. arms transfer policy has vacililated in 'Hamlet-like' fashion over the past 50 years, its application in specific instances is a product of how key decision makers answer four questions.[8] Does a particular arms package promote regional stability or fracture it? Are prospective recipients suitable targets for patronage? Are immediate economic benefits to the supplier offset by the potential domestic economic impoverishment of less well-heeled clients? Can the widespread sale of arms be reconciled with the ethical principles and political orientation of the American public? Answering these questions is essentially a political process to which no omnibus analytical regimen can be reasonably applied. Analysis of the military dimension of a proposed weapons transfer is an integral component of that process.

1.2 Military Analysis and Arms Transfer Policy

1.2.1 The Role of Military Analysis

Military analysis forms the nucleus around which other, less analytically tractable, considerations can be arrayed and is a mandatory element in each arms transfer proposal. The fact that the military aspects of an arms transfer constitute only a portion of the problem set does not derogate from the requirement that they be portrayed comprehensively and effectively. Indeed, testimony before any congressional committee, supporting or opposing an arms package, is invariably accompanied by a spate of figures charting the impact of the proposed transfer on the military capabilities of the recipient and the regional military balance. The assessment of the strictly military dimension of an arms transfer is not deterministic; neither is it insignificant.

In this context, the role of transfer related military capabilities analysis is to provide a 'policy assistance' mechanism to national decision makers. Military analysis must consider the impact of a proposed transfer on U.S. force posture, costs, and employment plans. More poignantly, it must assess the relevance of the transfer to the regional security situation, answering two questions. How does a given transfer affect the recipient's force posture and war making potential? How do the resultant changes in military force structure affect the regional military balance? In answering these two questions, attention need be paid not only to the quantities of assets involved but also to their capabilities in definable mission roles.[9] Judgment is an essential component in arriving at these determinations, but the analysis of aggregated tablular data simply cannot be avoided in the production of a useable assessment. Once the subject of tabular data is introduced, eyes role skyward; the spectre of impenetrable models of suspect relevance descends.

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8 The Shakespearian metaphor is borrowed from Harkavy and Neumann, *The Lessons of Recent Wars in the Third World*, p. 21.

9 Richelson et al. *Arms Transfer Control Criteria*, pp.61-62, 64-68.

1.2.2 Principles of Military Analysis

Analytical obscurity and irrelevance can be averted if some of the guidelines espoused by the Comptroller General are followed.[10] Even when applied at the aggregate level, a quantitative appraisal does provide a ". . . useful anatomical description of the extent to which . . . forces have improved or deteriorated relative to those of a putative enemy." As a composite index, the aggregated model necessarily masks some relevant distinctions and sacrifices the effects of synergy among its component parts. Its linear mathmatical form and the inclusion of simplyfing assumptions make these losses inevitable. Thus, its output cannot be applied independently but must be integrated with substantive non-quantitative analysis before conclusions can be drawn. Not rigorously scientific despite superficial appearances of precision, the output of a quantitative model is highly dependent on the variables entered into it, the assumptions made concerning them, and its mathmatical form. To be usefully applied, the model's input data must be valid and accesible, its assumptions explicit, and its workings transparent. Finally, expert judgment must play a key role not only in interpreting and leavening a model's output, it must also be embodied in the formulation of the model itself.

From a substantive perspective, a militarily-oriented policy assistance model must comprehensively capture the essential combat related properties of the systems being analyzed. When the nature of modern weapons systems is regarded, the relative combat contribution of key subsystems (e.g., air-to-air missiles, radars) is essential in the determination of overall capability.[11] The ability to compare combat potential within a weapon system category and across alternative mission areas is a necessary attribute, as is the requirement to aggregate combined weapon system capabilities at the force level. While aggregation inevitably compromises precision, the trade-offs need to be minimized and explicitly defined. Similarly, the analytical procedures chosen must be scrutinized to determine their inherent proclivities to generate systemic and random error within the context of analytical objectives.[12]

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10 See USGAO, *Models, Data, and War: A Critique of the Foundations of Defense Analysis*, pp.1-24, 54-55, and 148, for a discussion of the application of aggregated quantitative models and the rules which should govern them in the defense analysis process. While the GAO studies focuses on U.S. defense policy making, its lessons are equally applicable to the arms transfer problem.

11 See comment in Leiss et al, *Arms Transfers to Less Developed Countries*, p.174, which asserts that associated weapons subsystems are the key features which ". . . distinguish the military end use of a modern fighter-bomber." The principle is just as legitimately extended to other classes of weapon system.

12 This last set of principles is adapted from a list presented by Richelson et al, op cit., pp.83-86.

1.3 Research Methodology

1.3.1 Objectives

Acceding to this list of demands is a tall order, infrequently met. Regardless, the need for a systematized military analysis tool to support arms transfer and international security decision making is well established. A myriad of quantitative assessment techniques have been developed over the past 25 years by governmental agencies, commercial entities, and academic groups to meet the demand. None has achieved universal acceptance. The goal of this research is to propose a militarily focused aggregational methodology which capitalizes on the ground already covered and which adheres as closely as possible to the spirit, if not the letter, of the idealized principles described above. While all of the principles merit rigorous application, four can be singled out as receiving particular emphasis in the evolution of this methodology. First, the derivation of input data and the internal workings of the methodology are transparent. The sources, characteristics, and validity of each data element are described, as are the processes to which they are subjected. While this feature prolongs the descriptive process, it permits informed judgment on the methodology's utility. Second, the judgment of weapon system and intelligence experts was sought at each phase of the development process and integrated into methodology design and operation. Third, the focus throughout is on mission-specific combat output potential, not on the analysis of weapon system inputs. While inputs such as weapons inventories or system characteristics constitute necessary starting points, the combat capabilities which they engender are the determinants of military potential. Fourth, the limitations inherent in the methodology and the data which it considers are clearly identified to facilitate realistic integration of systemic outputs in subsequent case oriented analyses.

Two additional considerations, inferred from previously identified principles, also warrant mention. Methodological transparency is essential but not sufficient. The user of a policy assistance tool must also be able to manipulate it to satisfy specific lines of inquiry, rather than just being presented with static results. Consequently, a research objective is to develop a methodology with which a potential user can interact, performing iterative (sensitivity) analysis under varying conditions, priorities, and assumptions. Finally, in those instances in which methodological simplicity conflicts with substantive accuracy or relevance, substantive concerns take precedence wherever possible.

1.3.2 Limitations

Within the framework of these overarching objectives, some practical limits need to be drawn. The essence of the analytical process is theoretically unconstrained to a specific region or weapon system category. For developmental purposes, application of the methodology was restricted to the Middle East North African region.[13] This region was the recipient of 55% of the dollar value of all arms shipments to

13 Twenty-two countries were included on the regional set Algeria, Bahrain, Egypt, Ethiopia, Iran,

the Third World in 1983, continuing the trend established in the mid-1970's. The countries of the region are among the relative handful in the Third World with sufficient financial resources or super-power patronage to acquire significant inventories of modern weapon systems. Additionally, virtually all major systems in their inventories, with the exception of Israel's, are acquired internationally, and the subject of security assistance to the region dominates arms transfer policy debates within the U.S. political system. Finally, the series of recent and ongoing conflicts in the area provide some limited data on the combat application of these weapons systems as well as suggesting a military development pattern for other regions potentially embroiled in protracted conflict.

The investigation will also be limited to consideration of air weapons systems. Anthony Cordesman observes that airpower '. . . is the critical form of military power in the (Persian) Gulf', because of the regional geography, limited lines of communication, and the limited sustainability of ground forces.[14] Another experienced military observer comes to the same conclusion but extends its application to the rest of the region, noting that the effective use of airpower will be the determining element in the first rounds of any future Middle Eastern combat.[15] At a more practical level, aircraft transfers and inventories are highly visible, so relatively reliable data concerning them are readily available. Their visibility and cost propel them into the forefront of security policy concerns from both the supplier and recipient perspectives, enhancing methodological relevance. Finally, aircraft are the category of weapon system in which the author has the most practical expertise, such as it is. It should be noted that, although the field of inquiry for development of this prototype has been narrowed considerably from the outset, the principles underpinning it are extendable to other regions and weapons classes.

1.3.3 Organization

The basic philisophical groundwork laid, the remainder of the study will step through the elements involved in constructing a methodology for evaluating the military impact of air weapons transfers on the combat potential of Middle Eastern states and on the regional military balance. Chapter 2 will review some of the more salient techniques applied to the problem in the past, highlighting their advantages and disadvantages. Chapter 3 will propose a structure within which to conduct the analysis and identify its key elements. Chapter 4 outlines the data collection process, noting significant impediments and the methods used to surmount them. The procedure employed to reduce relevant data to analytically man-

Israel, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, Somalia, Sudan, Syria, the United Arab Emirates, Tunisia, the Yemen Arab Republic, and the Peoples Democratic Republic of Yemen. While not necessarily corresponding to a geopolitical definition of the region, this basket of countries is believed to capture its most interesting conflict and arms acquisition patterns

14 Cordesman, *The Gulf and the Search for Strategic Stability*, pp. 484-488.

15 Kemp, *Arms and Security*, p4. For an alternative view directed to the Third World as a whole, see Elliot A. Cohen, 'Distant Battles'.

ageable proportions is detailed in Chapter 5. Chapter 6 proposes a technique for combining input data into individual air weapon system and force aggregated combat mission outputs and displays selected results. Chapter 7 exercises the methodology in generating partial answers to potential arms transfer policy related questions, and the final chapter identifies some conclusions regarding the methodology and its potential application in assisting policy development. Throughout, the reader is cautioned to be sensitive to the limitations of the system, as well as its capabilities. Like any analytical methodology, it can accurately represent only a few of the more important attributes of the phenomena being investigated and does not assume to '. . .mimic the real world exactly.'[16]

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16 See Pyles, *The Dyna-METRIC Readiness Assessment Model*, p 31.

Chapter 2
METHODOLOGIES REVIEW

2.1 General

Quantitative techniques have been employed extensively over the past 25 years to estimate the impact of arms transfers on recipents' military capabilities and regional military stability. In different ways, they have all been confronted by the same problems: the identification of significant variables, the collection of reliable data, and the reduction of data to a common plane of comparison. Too often, the last problem has been solved at the expense of the first and second. This section will review some of the techniques employed historically and evaluate their adherence to the criteria outlined in the previous chapter.

2.2 Counting 'Dollars'

The most common medium of arms transfer analysis has been the comparison of the economic data associated with the transfer, often in the context of regional and national defense expenditures.[1] Monetary value is certainly not irrelevant. The trigger which activates the Congressional review process is, after all, a dollar amount. The two primary publications which catalog the international flow of arms, the Arms Control And Disarmament Agency's *World Military Expenditures and Arms Transfers* and the Stockholm International Peace Research Institute's *World Armament and Disarmament Yearbook*, devote much of their effort to establishing the valuation of individual and aggregated arms transfers. American debates concerning arms transfers are often predicated on package values, at least at the popular level.[2]

Reducing arms transfers to a common dollar measure has considerable merit and historical precedence, but its utility in the military analytical role envisaged here is limited. There is no doubt that dollar measures capture some sense of the magnitude of a transfer or of the priorities of Third World states.[3] However, the singular use of economic values as the basis for military analysis has two drawbacks. First and less significantly, the methodology through which transfers are valued is inconsistent and often

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1 Richelson et al, *Arms Transfer Control Criteria*, review several of the more notable dollar based arms race models. pp.16-47.

2 Of course, a disconcertingly large proportion of all American policy debates revolve around cost rather than functional effectiveness.

3 Cordesman convincingly contends that dollar to manpower ratios, for instance, are valid indicators of the extent of force modernization and support infrastructure development in *The Gulf and the Search for Strategic Stability*, p. 496. Another study, Hildebrandt's *Military Expenditure, Force Potential, and Relative Military Power*, employs an econometric methodology to translate military economic data into comparative power outputs.

opaque. If the contract price is used to value a transfer, intervening variables such as concessionary terms, offsets, and co-production arrangements influence the product, calling into question its reliability as a common frame of reference.[4] The assignment of monetary amounts based on an estimate of the analogous value of unit cost establishes a more level measurement plane.[5] However, even this approach suffers from a fatal flaw when applied to the assessment of military utility. There is simply insufficient correlation between the economic value of arms packages (or expenditures) and their military utility. The allocation of dollars among package elements varies greatly. Better than half of the dollar value of U. S. arms transfers to Saudi Arabia has been dedicated to infrastructure development, while virtually all of the dollar amount of transfers to Israel has purchased weapons themselves.[6] Even if this hurdle is cleared, a more basic problem remains. The most carefully sculpted dollar estimate provides no indication as to the mission adaptability, operational capability, or potential combat output of the system which the dollars buy.[7] The comparison of the economic value of arms transfers and military expenditures can legitimately detect trends and relative priorities at the systemic, regional, and national levels; but it fails to capture the military impact of weapons system transfers on national force structures and regional military balances.

2.3 Counting 'Beans'

One often applied solution to the inadequacies of dollar based measures has been the tallying of the weapons they buy. Certainly, the tabulation of the numbers of weapons systems being transferred and the inventories into which they are introduced is an essential element in any military analysis. But is it sufficient? The weight of opinion suggests not. Weekly news magazines are replete with charts showing stacked symbols of various categories of weapon system; so are the briefing screens of many Pentagon and Congressional conference rooms. At one level of abstraction, categorical quantitative measures such as these do depict general trends and gross patterns of arms transfer and force development. The condensation of discrete weapons systems into categorical totals makes for presentational simplicity and permits the application of some statistical techniques against homongenized data sub-sets.[8] However, for the type military analysis required to assist arms transfer policy makers, they are inadequate. The estimation of

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4 Laurance and Mullen, 'Assessing and Analyzing International Arms Trade Data', pp.13-21.

5 This technique is used by SIPRI in developing its arms flow figures.

6 Cordesman, *Jordanian Arms and the Middle Eastern Balance*, pp.30-31.

7 There is virtual unanimity among scholars investigating arms transfers on this point. See for instance, Richelson et al, op.cit. p.2; Baugh and Squires, *Arms Transfers and the Onset of War*, p.8; Leiss et al, *Arms Transfers to Less Developed Countries*, pp.29-31, and Sherwin and Laurance, *Using Data in Security Assistance Policy Making*, pp.80-82; among others.

8 See Leiss et al, op.cit., pp.35-116, for various examples of systemic analysis conducted at the weapons category level. Also, Baugh and Squires, op.cit., pp.8-12; and Lewis, Emerging Choices for the Soviets in Third World Arms Transfer Policy, pp.30-31

military utility (output) requires more finely grained data than is conveyed by the tabulation of the numbers of a category of weapons (input) which a nation possesses or will receive. Under most categorization schemes, an F-5E and an F-15E would both be counted as supersonic aircraft. The failure to account for the immense differences in capabilities between the two would cripple any serious attempt at guaging their impact on national force posture and regional stability.

More frequently, military and policy analysts concentrate on the analysis of weapons-specific inventories or transfer packages. Certainly more useful information is conveyed, but inventories alone provide a precarious perch from which to spring to any refined analysis of potential military output. A general impression of force posture can be estimated by considering the systems' respective roles and generations. In a vacuum, a listing of weapons tells us little about prospective combat output and its implications for a regional military balance. Phrased differently, reviewing inventories can determine if a force is being built up or if acquisitions just reflect a replacement of existing weapons. It does not indicate the thrust of a force's modernization or mission expansion.[9] If the qualitative differentiation among weapons and their mission adabtability to the particular employment environment is not considered, any resultant quantitative analysis will fall woefully short of providing the policy maker with militarily relevant assessments on which transfer decisions can be predicated. As one researcher notes, '. . . a mere enumeration of peacetime inventories. . . does *not* constitute an analysis of military capabilities.[10] The assessment of employable military force structure and realistic regional balances demands a more sophisticated measurement technique, one that considers the combat relevant qualities of the systems, their effectiveness in an operating environment, and the level of support a user can provide. Not only do the capabilities of the major systems themselves have to be considered, but also the contributions to potential combat effectiveness made by key subcomponents (e.g., missiles, radars). The upgrade of system components can often have nearly as profound an impact on the performance of a weapon as would its replacement.

Clearly, the estimation of the military impact of weapon systems transfers requires a more sensitive and flexible technique. While the reduction of arms transfers to a common economic measure or their consideration by category provide common ground for aggregate analysis, neither conveys the specificity of militarily relevant information required to project potential combat output. Detailed inventory analysis provides more granular information, but similarly lacks the performance related detail to permit all but the most general and speculative of assessments. The inventory approach also suffers from the drawback of not having a common base on which relative combat potential can be measured among national forces.

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9 Richelson et al cite the consideration of these four acquisition patterns as being essential to the determination of the a nation's force posture and its relevance to a regional military balance; op.cit., p.64.

10 Epstein, *Measuring Military Power*, p.131. Similar comments can be found in Sherwin and Laurance, op.cit., pp.82-83; Handel, 'Numbers Do Count', p.259; Leiss et al, op.cit., pp.117-124; Snider, *Arabesque*, p.6; and others.

Attacking these inadequacies, several researchers have developed alternative approaches which encompass performance related attributes.

2.4 Factor Analysis

In the mid-1970's, various studies grasped upon factor analysis as a technique well suited to the task of synthesizing performance characteristics into aggregate measures of weapon system capability. The earliest of the applications aimed at isolating dichotomous dimensions of aircraft performance characteristics and then extracting relative values or scores for each weapon on those dimensions. The dimensions were assumed to represent categories of mission (e.g., offensive, defensive) the execution of which was closely associated with the characteristics which contributed most significantly to their definition. Later studies took a more refined approach and developed factor models in which multiple dimensions were extracted and related not to mission but to system performance attributes (e.g., maneuverability) the relative values of which could then be combined to represent outputs in given mission areas. No matter the orientation of the effort, the factor analysis based studies demonstrated the capability to condense values for multiple performance characteristics into commonly based indices which could be integrated into force level analyses. In this regard, factor analysis deserves further attention.

2.4.1 Description

Factor analysis is recognized as a general scientific method for analyzing data. Originally devised by Charles Spearman in 1904 as a method of simplifying the complex phenomena determining intellectual ability, it has been refined and adapted over the years to explore patterns of relationships among data, to determine the structure of data, to reduce and eliminate redundancy in data, and to define a functional unity for the transformation of multiple variable values to a common scale.[11] As an exploratory tool, factor analysis uncovers underlying independent sources of *statistical correlation* among a body of input variables. Applied to data sets in which the relationships are unknown or only suspected, it defines a patterned statistical relationship attributed to an abstract underlying dimension. It falls to the researcher to categorize the *functional essence* of this underlying order or to suggest uniform causality.

Without delving too deeply into the statistical operation of the factor analysis process, a brief discussion of its characteristics will facilitate evaluation of factor analysis based studies. Two aspects of the process will be touched upon here, extraction of factors and rotation to a terminal solution. A third, factor score production will be treated later. Factors, or underlying dimensions, may be extracted by several

[11] Recent literature is replete with exhaustive discussions of the application of factor analysis to social and political science problems. The following have been drawn on heavily in this capsule treatment: R. J. Rummel, *Applied Factor Analysis* and 'Understanding Factor Analysis', Dennis J. Palumbo, *Statistics in Political and Behavioral Science*, Sam Cash Kachigan, *Multivariate Statistical Analysis - A Conceptual Introduction* and Jae-on Kim and Charles W. Mueller, *Introduction to Factor Analysis* and *Factor Analysis*

methods, with principal components extraction the method used in all of the studies under evaluation. Principal components analysis ingests a data file comprised of any number of variables and the values for relevant cases on those variables. The factor procedure first isolates the combination of variables which account for more of the total variance in the entire data set than any other combination of variables. This first component, or factor, represents the most inclusive summary of the linear relationships among the input data. A second component is then extracted which defines the second best variable combination and which accounts for the proportion of the variance not captured by the first. Thus, the second component or factor is orthogonal (i.e., at right angles) to the first. The process continues until sufficient factors have been extracted to account for the total variance in the data set. A 'loading' is generated for each variable on each factor which measures the degree to which the variable is involved in the factor. In other words, a variable loading represents the correlation coefficient between the variable and a given factor. By comparing loadings for all factors and variables, the researcher can identify those variables most closely associated statistically with a particular factor or multiple factors.

The initial factor solution is not unique, since other statistically equivalent combinations could well define a different array of underlying dimensions. Rotation to a terminal solution overcomes this uncertainly by mathmatically rotating the factor matrix to delineate distinct clusters of interrelated variables. Two rotational methods are commonly employed. Orthogonal rotation maintains the right angle separation between the vectors which best fit distinct variable clusters. Oblique rotation does not require that the factors be uncorrelated with each other and more precisely defines cluster boundaries.

2.4.2 Factor Analyzing Air Weapons Systems

2.4.2.1 Defining Factors

The earliest efforts to apply factor analysis to the evaluation of air weapons systems capabilities were launched by Michael Mihalka, Lewis Snider, and Allan LeGrow.[12] While each study had its unique aspects, the similarities among them allow their discussion as a group. Mihalka and Snider hypothesized that fighter aircraft would fall along two dimensions. Mihalka defined these as 'attack' and 'defense', Snider as 'interception/air superiority' and 'tactical support/ground attack'. Each selected variables (5 and 12 respectively) which he suspected would define one dimension or the other. True to form, the analysis defined the expected dimensions. The results of Snider's inquiry, which considered 162 aircraft, are depicted in Table 2.1, with some editorial changes.

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[12] Mihalka, *Understanding Arms Accumulation*; Snider, *Arabesque*; and LeGrow, *Measuring Aircraft Capability for Military and Political Analysis*

Table 2.1: Factor Analysis Of Combat Aircraft - Snider

VARIABLE	FACTOR 1	FACTOR 2
Production Year	.78	.18
Primary MIssion Speed	.93	.13
Maximum Speed	.98	.11
Service Ceiling	.88	.00
Thrust	.88	.20
Rate of Climb	.86	-.02
Take-off Weight	.21	.74
Payload	.22	.76
Ferry Range	-.01	.91
Combat Range	.10	.91
Radius-Internal Fuel	.13	.90
Radius-External Fuel	-.07	.86

Reviewing the factor loadings, the variables group around those factors which correlate to the most desirable capabilities for the respective missions, when Factor 1 is considered the air-to-air mission and Factor 2 the air-to-ground mission. However, an argument can be made that the selection of variables for analysis turned the process into a self-fulfilling prophecy. In particular, regard Factor 2. Three of the variables (combat range, and the two combat radius variables) tap essentially the same characteristic with only minor variation. A similar situation exists between ordnance payload and maximum takeoff weight. Not only does this mode of variable selection tell us little more than we knew about the weapons system mission adaptability coming in, the asymetrical representation of a functional attribute in this fashion can severly distort the solution.[13] More importantly, the gerrymandering of input variables produced some suspicious relative factor scores on each dimension. Soviet SU-7's and SU-20's, which are single purpose ground attack aircraft with relatively short legs and high top speed capabilities, scored most highly on the air-to-air dimension, while the F-4E outpaced the F-14 on the same attribute. These results were artfully rationalized, but the point remains that key mission-related performance variables were eliminated from consideration not on the basis of functional merit, but because they did not correspond to a predetermined typology.

LeGrow ascertained this deficiency and added variables to the data set which attempted to capture the effect of weapons on mission capability (number of gun barrels, missile algorithm). He also eliminated the most redundant variables from the previous set and added ones with more aeronautical relevance (thrust-to-weight ratio and wing loading). Analyzing 29 aircraft, he extracted three factors, as shown in Table 2.2.

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13 Rummel, *Applied Factor Analysis*, p.211

Table 2.2: Factor Analysis Of Combat Aircraft - LeGrow

VARIABLE	FACTOR 1	FACTOR 2	FACTOR 3
Maximum Speed	.91183	-.16005	.15425
Ceiling	.90017	-.14516	-.10637
Thrust	.81375	.33873	.27959
Rate of Climb	.85771	-.17088	.31275
Take-off Weight	.62739	.68222	-.04521
Payload	-.22243	.91291	.07798
Combat Range	-.06186	.90778	.01947
Combat Radius	-.09686	.90804	.00532
Thrust-to-Weight Ratio	.54453	-.32122	.54158
Wing Loading	.07857	.34959	-.83717
Gun Barrels	.07818	.13349	.88188
Missile Algorithm	.30709	.24849	.52984
Production Year	.27103	.40090	.52844

Reviewing the results, LeGrow noted that the presence of a third factor complicated interpretation and that the elimination of redundant variables and the insertion of other combat relevant attributes produced an overall matrix in which the distinctions were no longer as clearcut. For instance, thrust-to-weight ratio loaded moderately on Factors 1 and 3, while several others (e.g. production year, wing loading, thrust) loaded heavily on one variable and moderately on others.[14] LeGrow postulated that the combination of Factors 1 and 3 appeared to best represent air combat capability, with Factor 2 capturing air-to-ground qualities. While the combination of scores on Factors 1 and 3 produced performance rankings which were intuitively reliable, the scores generated for the second factor contained some serious anomalies. The F-16, which has a significant ground attack capability, ranked below the F-5E on that factor, while the F-14A, an interceptor, was exceeded only by the A-6E and the A-7D. To further test the procedure, LeGrow considered only aircraft with an air-to-air mission and reduced the number of variables in a second factor problem. Again, three factors emerged, but with different and functionally contradictory variable loadings. Regarding LeGrow's results, the volatility of the factor analysis process becomes clear. The alteration of variables or cases can produce drastically different dimensions, some of which are not easily abstracted to higher order concepts such as mission output. As he also pointed out, the combination of multiple factors to produce a mission score is an arbitrary process if only factor analytic results are considered.

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14 The author believes that LeGrow's third factor would have decomposed into two factors had he considered a larger number of cases. One factor would have been defined largely by the weapons related variables, the second by thrust-to-weight ratio and wing loading (negative loading). Test runs on a data base with 86 aircraft tended to confirm this estimate. Thrust-to-weight ratio is directly related to maneuverability, and wing loading is related to it inversely from an aeronautical perspective.

The Analytical Assessments Corporation's (AAC) study team, which included Lewis Snider, applied a more sophisticated factor analytical methodology to the problem. Most importantly, they increased the number and aeronautical relevance of the variables under analysis and defined factors which purported to represent system attributes rather than combat mission outputs. The study aimed to use factor analysis to determine dimensions of fighter capabilities which would be 'invariant' regardless of minor alterations in variable selection, case compostion, or rotation technique. Initially, all aircraft were factor analyzed in a single model. Explaining the at times unrealistic results produced some inventive but aeronautically specious formulations.[15] The analytical problem was consequently segmented, with separate analyses conducted for interceptors and air superiority fighters and for ground attack and close air support aircraft respectively. Aircraft were treated both as 'launch platforms' (internal weapons only) and as full weapons systems (external ordnance included). Delineating mission groupings prior to analysis averted many of the interpretation problems and spurious results which confronted Snider and LeGrow. It also permitted the independent analysis of multi-role fighters in each mission area. Furthermore, distinct analyses were accomplished for air-to-air and air-to-ground missiles, the results from which were integrated into the overall air weapon system model. The result was a smorgasbord of analytical options.[16]

One data set and model will be discussed here. It analyzes interceptors and air superiority fighters as weapon systems with capability scores for air to air missile systems included. This analysis was selected because it is the most sophisticated of variable combinations evaluated which also vividly illustrates the pitfalls of attempting to stretch a technique past its limits. Fifteen variables observed for 69 interceptor and air superiority fighters were analyzed, with five factors extracted. The names assigned these factors and the variable loadings derived are depicted, with minor stylistic editing, in Table 2.3. Only loadings of 0.5 or higher are shown to highlight the factors.

Before discussing the results, some observations on the variables themselves are warranted. First, year of production is intended as a surrogate representing relative technological sophistication or modernity.[17] While this contention is superficially pleasing, its underlying assumption is invalid. Consider, for instance, three U.S. aircraft, all of which were flown for the first time within four months of each other in 1972. The F-15 is a leading-edge high technology fighter; the F-5E is a considerably less sophisticated export aircraft; and the A-10A is a technologically austere ground support fighter. When aircraft have different design and cost goals, knowing the year of production conveys little as to their relative techno-

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15 See the convoluted explanation as to why the F-14 scored lower than the F-5 as an interceptor air superiority fighter as an example, pp.123-124.

16 In all 18 analyses were conducted at the air weapon system level, with six for missiles. Factor rotation techniques were varied to control for systemic bias. These are presented in toto in Richelson et al, op. cit., pp. 144-192.

17 The same variable was also used by Snider and LeGrow.

logical sophistication. The materiality of the variable diminishes even more when generational comparisons are made between aircraft produced by different nations, whose own technological capacities are far from even at the same point in time. Secondly, the variable 'Mission Potential' was constructed by multiplying the combat radius of an aircraft by its mission speed. Intended to illustrate the point that high speeds can reduce combat endurance, the combinational form has no aeronautical precedent and ignores the fact that mission speed is one of the factors, along with ordnance load and flight profile, which is involved in the determination of combat radius in the first place. Third, the 'missile guidance' variable was derived from a separate factor problem in which the attribute was described by two dichotomous variables, 'infra-red guided' and 'semi-active radar homing guided', which were assigned nominal valuations (0 or 1). Logically, these varied inversely for any given case, defining a factor with high (.98) positive and negative loadings. In the factor scoring process, which will be described below, the dichotomous loadings cancelled each other out producing 'missile guidance scores' which were predicated on the values for all variables *except* the guidance value.

Table 2.3: Dimensions Of Air-To-Air Fighter Capabilities

VARIABLE	ENERGY/ TECH-NOLOGY	WEAPONS SUITE	ARMA-MENT	ENDUR-ANCE	MANEUVER-ABILITY
Production Year	.75280				
Rate of Climb	.94426				
Combat Ceiling	.79378				
Combat Speed	.91804				
All Weather	.50267				
Payload	.90748				
Mission Potential	.70984			.54982	
Combat Radius				.96576	
Thrust to Weight					.89728
Wing Loading	.71315				-.54015
Muzzle Velocity			.97935		
Rate of Fire			.98072		
Msl Lethality		.89930			
Msl Envelope		.87492			
Msl Guidance		.86691			

Glancing at Table 2.3, the effects of these variable selection anomalies can be seen. Mission potential loaded significantly on the energy and endurance factors, a predictable situation since the variable was created by multiplying combat radius times combat speed. Otherwise, the results are largely non-

contentious, showing predictable statistical affinities among variables. The missile and gun variables define factors representing the air-to-air missile suite and gun armament respectively. Wing loading shows a negative relationship to the maneuverability factor, as it should.[18] However, wing loading also has an even higher positive loading on the energy technology factor, an observation requiring clarification. While the resultant variable groupings could have been postulated intuitively, the addition of the statistical dimension offers the opportunity to create multi-variable indices which reflect the relative capability of each aircraft on each combat related attribute.

2.4.2.2 Extracting Factor Scores.

The key utility of factor analysis in this context is its ability to generate scores for each case on the underlying dimension or factor. Unfortunately, its promise fades when it is employed in this role at the air weapon system level. The scoring process entails two salient features. The absolute values of all variables in the set weighted proportionately to their involvement (positively or negatively) in the factor are considered in the solution and are summed to yeild the factor score for a case. The operative assumption is that each factor is a linear combination of the case values for every variable in the problem set. Thus, a variable which is largely unrelated statistically (and perhaps not at all functionally) to a factor has a definable impact on the score. Secondly, the absolute values for the variables are converted to standardized scores with a mean of zero and a standard deviation of one before the scores are rendered. Consequently, some scores are negative values even when all variables load positively on the factor; and all scores are measured on an interval scale.

From a technical perspective, the factor score coefficient matrix (F) is derived from the rotated pattern matrix (A) according to the formula:

$$F = (A^T A)^{-1} A^T$$

Score coefficients are consistent with the weight and direction of the factor loadings. Variables with high factor loadings receive higher score coefficients relative to their loadings within the confines of the *entire problem set*. Weaker loadings produce coefficients which tend toward zero, and negative loadings generate negative coefficients.[19] A factor score (f) is then developed for each case by summing the products of the factor score coefficients (F) of all variables in the factor problem and the standardized values of each case (z) on those variables. In equation form, the factor score for a case (f_1) in a three variable factor problem would calculated by the equation:[20]

[18] In earlier tables which did not include the missile variables, wing loading loaded positively on the factor asserted to represent maneuverability, a questionable relationship aeronautically.

[19] If the alternative regression method of extracting score coefficients is used, tests indicate variables with the weakest positive loadings will also be awarded negatively signed score coefficients.

[20] This description and equations are adapted from the examples offered in Nie et al *Statistical Package for the Social Sciences* Second Edition, pp. 487-489. The formulae cited apply to factors extracted by

$$f_1 = F_{var1}z_1 + F_{var2}z_2 + F_{var3}z_3$$

The problems stemming from the first characteristic can be deduced from a review of the data in Table 2.4, which is an unblanked version of Table 2.3.

Table 2.4: Dimensions Of Air-To-Air Fighter Capabilities

VARIABLE	ENERGY/ TECH- NOLOGY	WEAPONS SUITE	ARMA- MENT	ENDUR- ANCE	MANEUVER- ABILITY
Production Year	.75280	-.18566	.36325	.46583	-.19166
Rate of Climb	.94426	-.11167	.03775	-.16755	.07555
Combat Ceiling	.79378	.36669	-.31621	.08626	.28050
Combat Speed	.91804	.01481	-.07273	.16637	.24171
All Weather	.50267	-.37841	-.48219	.47030	.25789
Payload	.90748	.04379	.04384	.24689	-.07155
Mission Potential	.70984	.14295	-.19642	.54982	.24850
Combat Radius	.13473	.15801	-.10303	.96576	.06441
Thrust to Weight	.21866	-.29951	.11426	.09139	.89728
Wing Loading	.71315	-.32802	.01955	.11413	-.54015
Muzzle Velocity	-.02070	-.11725	.97935	-.03979	.13076
Rate of Fire	.00287	-.14115	.98072	-.09275	-.00497
Msl Lethality	.18269	.89930	.03031	-.25055	-.12790
Msl Envelope	.07271	.87492	-.33946	.32456	-.00899
Msl Guidance	-.10591	.86691	-.09772	.21867	-.30998

Looking at the factor which allegedly captures air-to-air missile capability, the missile performance variables load positively. However, all-weather capability has a moderate negative loading, as does thrust-to-weight ratio. Thus, the score for a missile mounted on an technologically superior aircraft would be less than the score derived for the same missile mounted on an inferior platform. This scoring quirk is particularly nettlesome when one considers that all radar guided missiles are dependent on an air-intercept radar (an attribute of an all-weather system) for their guidance.[21] A similar relationship prevails for gun effectiveness, the score for which would be diminished by the value of an aircraft's all-weather capability, combat ceiling, missile launch envelope and others. Scores for the maneuverability attribute would be diminished as a result of a later production year (modern technology surrogate) while being enhanced by the presence of an all-weather radar and lessened if assigned missiles had more capable guidance systems.

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principal components analysis.

21 If the weak negative loadings for two other energy technology variables, production year and rate of climb, are considered, the situation deteriorates further.

Observations of this type could be made indefinitely. The essential point is that factor scoring conducted at the weapon system level forces the inclusion of functionally irrelevant data in the computation of values for discrete attributes. A defense of this characteristic has been advanced which contends that it captures the tradeoffs which must be made between some attributes in aircraft design.[22] While this contention might seem logical in a very narrow sense (e.g., maneuverability or speed being reduced to permit greater payload in a similar generation of aircraft), it ignores the advances which permit simultaneous improvements in multiple attributes. More poignantly, it is largely invalid when applied across subsystems, many of which are aircraft non-specific and which are developed independently of each other. Most U.S. aircraft can carry a version of the AIM-9 and are fitted with an M61A1 cannon. The two subsystems are technologically unrelated, and any scoring system which diminishes the value of one because of the presence of the other is flawed.[23]

The flaw in the 'vertical' (i.e., intra-factor) scoring process has a horizontal analog. The AAC study and others compute total system capability as an unweighted linear combination of factor scores denominated by the number of factors involved. Consequently, the value which describes the capability of the aerial gun has the same relative weight in the computation for air-to-air effectiveness as does energy or maneuverability. Not only is this supposition counterintuitive, it is roundly contested by the results of an aircrew survey that established that an aerial gun has a relative utility of .067 in an air superiority role and .043 in an interception role.[24] An unweighted linear computation of factor scores overrepresents the role of the gun by more than 200%. The combined influence of these two scoring traits produces relative values at the air weapon system level which obscure more than they illuminate.

2.4.2.3 Using Factor Scores.

The mathmatical process by which factor scores are measured presents another, although far less intimidating, problem. Because factor scores are computed on a standardized scale, some have negative values. While these values accurately portray the distance between cases and can be used in direct comparisons of cases on a given factor, they are not conducive to further combination. Earlier researchers attacked the problem by adding a constant to the set of scores which raised the lowest negative score to a desired threshold (e.g., 0.1 or 1). LeGrow demonstrated that the use of a constant in this fashion preserved the interval relationship among the scores but distorted their ratio relationship. While the implication that a

22 See Snider, op.cit., p.55, for one such assertion.

23 A statistical consideration concerning subsystems is also relevant. Since the input variable values for any given subsystem would be entered multiple times reflecting their fitting to several aircraft, they would constitute what Rummel terms an 'a priori' factor, detracting from the patterned variation essential to the derivation of meaningful factor groupings.

24 Supporting survey results, seven percent of the Israeli air kills over Lebanon in 1982 were achieved by gun shots. See, Lambeth, *Moscow's Lessons from the 1982 Lebanon Air War*, pp. 10-11; and Carus, 'Military Lessons of the 1982 Israel Syria Conflict' p.268.

valid ratio relationship existed in the first place was incorrect, the observation that the addition of a functionally irrelevant constant created a pseudo-ratio relationship of arbitrary significance stands.

The AAC study took a more elaborate approach to raising negative values above zero by applying the expression for calculating a T-score ($10*Z+50$) to the raw factor score but acknowledged that the transformed scores still lacked true ratio properties. Consequently, the ratio of capabilities between two systems could only be inferred. Some examples were offered which asserted that meaningful comparisons between alternate weapon systems packages could still be made as long as the limitations of the data were recognized.[25]

2.4.2.4 Factor Analysis Summary.

Factor analysis constitutes a powerful tool for reducing large bodies of data to *statistically* valid composite indices. Applied to the evaluation of combat aircraft, it produces results which do not always embody a commensurate degree of *operational* validity. As demonstrated above, comprehensive variable selection is crucial, and factor results can prove erroneous if the variables considered do not represent the bulk of a system's aeronautically and operationally relevant attributes, to include those of its subsystems. Additionally, factor results are sensitive to relatively minor variations in variable and case composition, so their ability to define 'invariant' dimensions for fighter performance over differing spatial and temporal domains is suspect. The extrapolation of the raw factor analysis output to operationally pertinent composite indices is crippled by three characteristics when applied at the system level. Functionally irrelevant information is included in generating factor scores. The combination of scores for multiple factors into a composite is arbitrary and often produces illogical results. Finally, the composite indices created from factor outputs are interval level measures which lack the mathmatical properties to permit their aggregation at the force level.

2.4.3 Multi-Attribute Utility Theory

To overcome several of these deficiencies and to account for intangibles such as operator proficiency and support capability, LeGrow explored three alternate techniques for creating composite indices of fighter capabilities: paired comparisons, successive intervals method, and multi-attribute utility theory (MAUT). After experimenting with each, he concluded that MAUT was the '. . .only technique comprehensive enough to deal with capability as more than just a combination of performance characteristics. Following his lead, Lowell Jacoby applied MAUT to an assessment of ship sea denial capabilities.[26] The fact

[25] See Richelson et al, op.cit., pp. 218-220 for a discussion of methods of dealing with the level of measurement problem. While this author has no quarrel with their methodology, he takes exception to their contention that interval nature of factor scores is the 'most serious drawback' to their use at the systems level.

[26] See LeGrow, op.cit., pp. 119-137 and Jacoby, *Quantitative Assessment of Third World Sea Denial Capabilities*, pp.58-154. The discussion of MAUT here is taken from these two publications and

that MAUT permits the consideration of multiple variables, produces ratio measurement scales, and involves expert judgment in defining combinational rules marks it as having significant promise in the analysis of air weapon system capabilities.

2.4.3.1 Description.

MAUT is a general approach for combining the utility values of multiple attributes into a single measurement of utility under a specified set of circumstances. A panel of experts is requested to develop a scale for each variable which reflects the relative utility of the variable's absolute values in a given scenario. Through this process, the absolute values of multiple variables are transformed to a common measurement scale (utils). Each util scale runs from 0 to 1. As the first step in the development of the utility function curve, judges are requested to identify the absolute value at which the variable under consideration has no utility and the absolute value at which its utility in the postulated scenario peaks. These absolute values anchor the opposite ends of the utility function curve. Judges are then requested to match successive increments of change in a variable's absolute value above the lower anchor point to corresponding increases in utility up to the maximum useful value which is assigned a utility score of 1. A utility curve is constructed by connecting these discrete points. Through this procedure, a natural zero point is established, and the utility scores are assumed to have ratio properties. The absolute value for each variable is converted to a util value by imposing it on the respective utility function curve. Their values now transformed to commonly based ratio measures, the variables can be combined to define the relative value of multi-variable attributes and multi-attribute systems.

The combinational rules which govern aggregation at the attribute and system levels are also the product of expert judgments as to the relative importance (weight) of the attributes or system's components. The technique assumes that the experts will make rational choices in developing utility scales and identifying combinational weights, seeking to maximize expected gains and minimize expected losses at each step in the process. Effective application of the technique is dependent on a clear statement of the inquiry's purpose and operative scenario, the selection of variables which capture the pertinent aspects of the phenomena under investigation, the expertise of the judges, and their access to sufficient information concerning the variables, attributes, and systems which they are evaluating.

2.4.3.2 Application

To test the theory, LeGrow devised a scenario to score fighter aircraft in a Middle Eastern air superiority engagement. He identified three relevant components and the variables which defined them. These are shown in Table 2.5.

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from critiques contained in Richelson et al, op.cit., pp. 88-101, and Sherwin and Laurance, op.cit., pp. 95-100.

Table 2.5: Air Superiority Fighter Performance Components

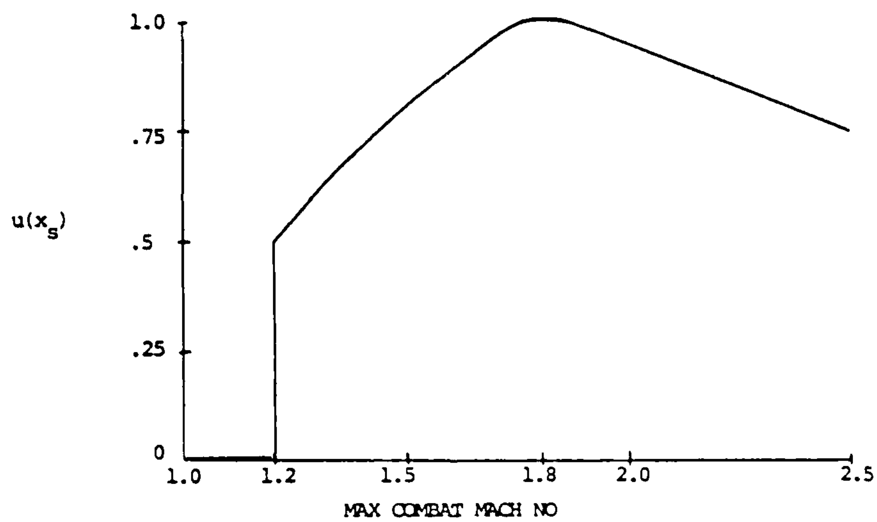
PLATFORM	PAYLOAD
Maximum Speed	Missile Range
Thrust to Weight Ratio	Missile Speed
Wing Loading	Firing Envelope
Combat Radius	Number Guns

EMPLOYMENT FACTORS

National Technical Capacity
National Pilot Proficiency

A two judge panel devised utility function curves for each variable and specified weightings for each within its component. A sample utility curve for maximum speed is shown in Figure 2.1

Figure 2.1: Airspeed Utility Curve



Regarding this curve, an application question arises. While there is no doubt that speeds in excess of Mach 1.8 are of diminished utility in air superiority engagements, would an aircraft with the technical potential to exceed Mach 1.8 then be assigned a lower utility score derived from the downward sloping end of the curve? From the scoring tables in the Appendix, it appears that this was the case. If so, the

score extraction ignores the fact that an aircraft which has a maximum speed capability of Mach 2.5 can also usually operate at Mach 1.8. The same problem also appears to affect the extraction of utility scores for the range value. One other problem area emerged in reviewing LeGrow's individual utility curves. The utility function for national technical capacity was developed with a list of countries along the y-axis which were then assigned utility values. With no absolute measures of technical proficiency to govern the assignment of utility values, the utility function curve was defined by intervals between the countries arrayed at the bottom. The approach appears to be a misapplication of the utility concept, since the cost-benefit rationale which is supposed to govern curve development is abrogated. In a broader perspective, MAUT does not appear adaptable to the analysis of problem sets which include nominally or ordinally measured variables.

These observations aside, LeGrow combined the extracted utility values in accordance with the intervariable weightings assigned by the judges and then multiplied the platform and payload sub-totals to generate a final weapon system score independent of country. The aircraft and their utility values are depicted in Table 2.6.

Table 2.6: Fighter Utility Scores - Air Superiority

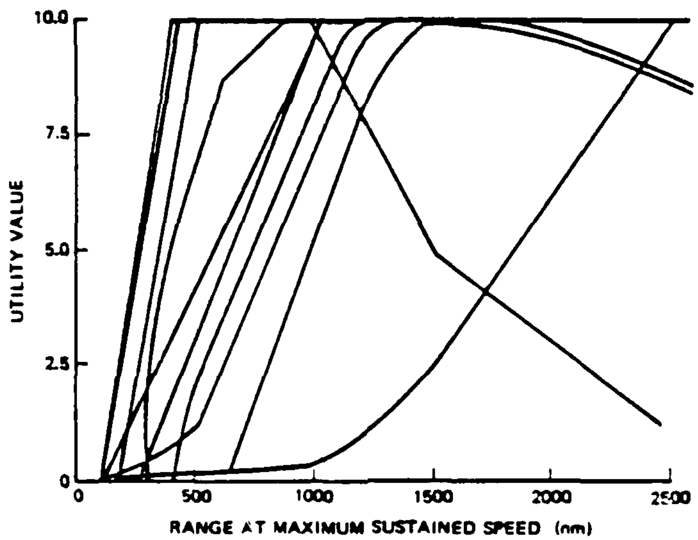
AIRCRAFT	WEAPON SYSTEM UTILITY
F-16	.96
F-15	.86
F-14	.79
F-4E	.47
F-5E	.48
Mirage IIIC	.69
MiG-19	.68
MiG-21	.62
MiG-23	.58

Unfortunately, utility scores show some of the same vagaries that plagued factor scores. The utility value for the MiG-19 identifies it as more capable than all fighters except the latest U.S. fighters and the Mirage IIIC and almost 50 percent more capable than the F-4E. The F-4E sits lowest in the group, a ranking not merited by its weapons suite or combat avionics. Three factors seem to have forced these unsuitable results: insufficiently comprehensive variable selection, the above noted scoring idiosyncracy, and using a multiplicative combinational technique at the system level.

While Jacoby's study considered sea denial ships rather than aircraft, a partial review of his findings illuminates some other features of the mult-attribute utility technique. Proceeding from LeGrow's

exploratory effort, Jacoby launched a full-fledged MAUT inquiry. Most significantly, he employed multiple independent judges to enscribe the initial utility function curves rather than tasking two judges to develop consensus curves. The profound differences of opinion among 11 judges concerning one variable, range at maximum sustained speed, are exhibited in Figure 2.2. Similarly fragmented results were obtained for virtually every variable (15) in the problem set.[27]

Figure 2.2: Utility Function Curves - Range at Maximum Speed



This significant and largely unpatterned variation in responses presented an interpretation and application challenge and illustrates one of the drawbacks of employing MAUT in this type of investigation. Jacoby tested two methods for condensing multiple utility assessments. Just one will be discussed to illustrate the problem. One alternative is to mathmatically synthesize a single utility function curve from the curves described by the judges.[28] He found this technique to be fraught with mathmatical complexity and prone to error. For illustrative purposes, the composite utility function curve derived from the curves depicted in Figure 2.2 is shown in Figure 2.3.

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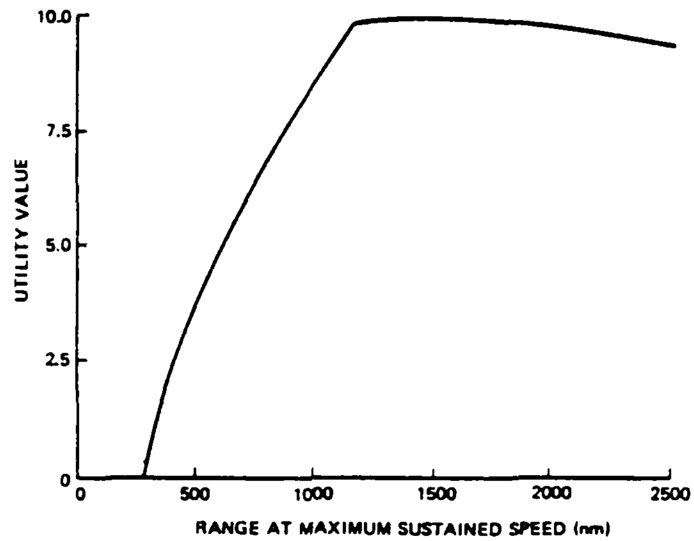
27 Jacoby also considered the same variables under two different employment scenarios, causing each judge to create as many as 30 utility function curves.

28 The other method is to score each case on each of the initial utility curves, sum the results, and determine an average utility score. This is the method finally used by Jacoby. Like many of the MAUT-related procedures, this solution is extremely time and manpower intensive when regarding a large number of systems and employment scenarios.

Figure 2.3: Composite Utility Curve - Range at Maximum Speed



Given the range of disparate opinion, the measurment validity of the composite curve is suspect. Perhaps more significantly, the wide range of responses reveals the daunting intellectual challenge confronting a panel of experts in determining precise value/utility matchups in a multi-faceted inquiry of this type. Each judge is required to make what amount to hundreds of discrete judgments which are consistent within the variable being scored and across the family of variables.[29] Individual judgments are also predicated on the respondant's access to sufficient data concerning the variable and his interpretation of the scenario under which it is scored. Differing scenario interpretations probably contributed to much of the variance, even though Jacoby took great pains to detail the operating environment. The entire MAUT-based sea denial study constitutes a significant contribution to the field of military analysis and should be reviewed in toto by those considering application of the technique. However, for the purposes of this inquiry, it discussion will terminate here with the identification of those attributes relevant to the inquiry at hand.

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[29] As a respondant to two MAUT surveys, the author has first-hand experience with the the difficulty of maintaining even meager consistency. The effort is so energy and time consuming that the potential for obtaining a broad sample of rigorously derived judgments is slim.

2.4.3.3 Multi-Attribute Utility Technique Summary

The most rewarding asset of applying MAUT to the analysis weapon systems' combat capability is that it incorporates informed expert judgment in all phases of the assessment process, an essential attribute of any reliable methodology. In particular, it offers an attractive solution to the combinational dilemma identified by LeGrow in aggregating individual factor scores. Additionally, it produces ratio level values measured from a common base which can be inserted in subsequent force level capability calculations. Conversely, MAUT suffers from a number of conceptual and structural liabilities. It does not legitimately scale nominally measured variables. Its implementation is cumbersome and prone to random judgmental influences which are well nigh impossible to isolate. Available methods for synthesizing disparate judgments are unsatisfying. While not a liability per se, MAUT's results are largely determined by the selection of input variables and the validity of the data which describes them, a trait it shares with virtually every other approach. Multi-attribute utility technique resolves several of the more pronounced deficiencies identified in other quantitative methodologies but introduces some of its own.

2.4.4 TASCFORM Force Modernization Model

The Analytic Sciences Corporation (TASC) developed a third quantitative methodology which incorporates the performance characteristics of air weapons systems into combat relevant capabilities indices which can be evaluated on their own or aggregated into force level assessments. The air weapons assessment model, TASCFORM™-AIR, is a subset of a family of analytical models which address the subject of general purpose force modernization. The original models were developed in support of the Office of Net Assessment, Office of the Secretary of Defense, and have subsequently been applied to specific research questions in support of it and other government agencies.[30] The TASCFORM methodology is not a statistical technique as such. However, it incorporates many of the same attributes addressed by the methodologies discussed above while maintaining the flexibility to consider meaningful attributes which are not amenable to interval or ratio level measurement. Consequently, its array of variables more comprehensively defines the combat relevant attributes of an air weapon system than earlier efforts. It combinational philosophy is predicated on mission specific expert judgment and can be expanded to account for the effect of difficult to quantify factors such as operator proficiency, maintenance and logistic support, and command, control, communications and intelligence (C^3I) support.

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30 See, for instance, Congressional Budget Office, *Tactical Combat Forces of the United States Air Force*, pp. 31-50; and *Assessment of Egyptian-Middle East Tactical Aviation Modernization* (Classified). A detailed description of the TASCFORM-AIR methodology is contained in Vogt, *The TASCFORM Methodology: A Technique for Assessing Comparative Force Modernization*, pp. 2-1 to 2-55. TASCFORM is a trademark of The Analytic Sciences Corporation.

2.4.4.1 Description

The TASCFORM process follows a hierarchical path. A basic airframe system figure of merit is computed considering the values for four attributes (payload, range, maneuverability, speed) indexed to the value for a baseline system (the F-4B), weighted according to expert assigned values, and summed for each mission category. In all, three mission areas (air combat, surface attack, anti-submarine warfare) encompassing 13 distinct employment roles are evaluated for 112 fixed and rotary wing aircraft. Basic airframe scores are then modified through a series of calculations which account for the contribution of subsystems (target acquistion, navigation) and associated attributes (countermeasures susceptibility, survivability) to mission performance. A final weapon system step adjusts performance indices to account for the systems' relative obsolence and sortie rate production potential. Finally, force level projections can be accomplished by allocating candidate inventories across mission areas and multiplying them by the corresponding performance indices. If desired, the resultant force level measures of merit can be further modified to account for the effect of intangibles such as C^3I, relative aircrew proficiency and the like in producing a final Equivalent Force Performance measure of merit. In all, TASCFORM-AIR represents a comprehensive, powerful, and operationally sensitive technique for quantitatively assessing the qualitative aspects of force modernization. While designed initially to address the US-Soviet force balance, it is equally applicable to assessments of the force structure and military balance aspects of arms transfer policy support.

2.4.4.2 Application

The full TASCFORM computational skein is too extensive to unravel in this overview. Just a few of its features will be highlighted to set the stage for further methodological development. As noted earlier, the initial calculation is anchored at the airframe level and considers payload, range, maneuverability, and useful air speed indexed to the corresponding value for the F-4B. A single variable is designated to represent each attribute. For instance, maneuverability is pegged to the indexed value for specific excess power (P_s). Herein lies the first deficiency in the approach. The selection of a single variable might well discard relevant information concerning an attribute which encompasses two or more dimensions. To use the manueverability example, P_s accounts only for energy maneuverability (acceleration), so the factor of lateral maneuverability (rate or radius of turn) is lost. Indexed values are modified by avionics and weapon system attributes to reflect their 'tactical impact' on basic airframe performance. The concept is solid, but execution is less precise than need be in two areas. Target acquisition capability is divided into four categories (clear day, clear night, limited all-weather, good all-weather) which are assigned subjective values (1.0, 1.0, 1.2, 2.0). This approach prohibits measurement of the very significant capability differences which obtain among target acquisition systems within these categories. For instance, the F-4F's

AN/APQ-120 radar and the AN/APG-70 being developed for the F-15E would receive equivalent scores; but there is no doubt that the actual performance capabilities of the two systems vary considerably. A similar situation prevails in the air-to-air missile category where differentiation is only made between guidance type and engagement mode (visual range or beyond visual range). Again, the combat relevant differences between missiles such as the all-aspect infra-red guided AIM-9L and the rear hemisphere only AA-8 are not captured. Similar observations could be made concerning the survivability and sortie rate attributes.

2.4.4.3 TASCFORM Summary

TASCFORM-AIR establishes an indisputably superior framework for the aggregation of combat relevant attributes into mission specific outputs. It incorporates expert judgment into a clearcut, flexible, and transparent combinational process and permits the consideration of important but intangible variables. As opposed to the other analytical models, it addresses the critical role target acquisition systems play in modern air warfare as well as permitting adjustments for employment related factors. On the debit side of the ledger, TASCFORM fails to make sufficiently granular assessments of the differences between specific subsystems in some cases. In the same vein, its reliance on single variables to describe primary system attributes sacrifices a measure of descriptive and operationally relevant information, perhaps unneccessarily. The negative aspect of this last feature might be partially offset by the implementational flexibility it offers.

2.5 Methodologies Summary

Regarding the sampling of military analysis methodologies which might be used to assist arms transfer decision making, it is obvious that the dollar valuation and inventory approaches are inadequate on their own to generate sufficiently informative assessments of the impact of an arms transfer on a nation's force posture in a vacuum or in a regional context. They simply do not measure or aggregate information reliably linked to combat capabilities.

Factor analysis is capable of aggregating many of the essential elements but is volatile and unreliable when applied at the weapon system level. The forced inclusion of irrelevant data in producing specific attribute indices is factor analysis' greatest weakness, followed by its inability to process nominal data without output distortion. Additionally, a pure factor solution provides no operationally legitimate rationale for combining values for multiple attributes into a single system index, and the values themselves lack the ratio properties required for force level aggregation.

Multi-attribute utility theory's greatest strength is its inclusion of expert judgment in all phases of the evaluation, providing a particularly effective scheme for combining values for multiple variables and attri-

butes into a single measure of effectivess under a given scenario. However, it does not legitimately accommodate nominally described variables, and its administration is prohibitively cumbersome when applied to a subject with more than a handful of attributes and scenarios.

The TASCFORM methodology is functionally comprehensive, situationally flexible, and operationally transparent and makes effective use of expert judgment. Variable input is unconstrained by measurement scales, and system output is well suited to modification and higher order aggregation. Its most pronounced drawback is a proclivity to over-simplify input data, masking significant performance differences within generic categories.

In essence, no one methodology provides a holistic solution to the problem of incorporating qualitative information into quantitative military assessments. The common thread which connects them is a requirement for comprehensive mission relevant variable selection and thorough data collection and preparation. Since the application of any aggregation technique will succeed or fail on the basis of these fundamental operations, variable selection and data collection will be addressed in the next two chapters. Subsequently, data reduction and aggregation techniques which capitalize on the strengths of the aforementioned models and minimize their weaknesses will be discussed.

Chapter 3
VARIABLE SELECTION

3.1 Structuring the Problem

3.1.1 Defining Components

Before individual measurement variables are considered, it is prudent to structure the research question more elaborately, identifying key components and their subcomponents. The importance of this step cannot be understated since even, "a highly sophisticated statistical analysis can rarely if ever compensate for a poorly conceived project or a poorly constructed data collection instrument."[1] The problem at hand is to develop a measurement technique which assesses the impact of air weapons system acquisition on the air combat potential of Middle Eastern air forces. To structure or operationalize the problem, at least two major components must be meshed:

- The performance potential of pertinent air weapon systems (aircraft plus specific subsystems) in definable employment categories (air weapon system combat potential).
- The numbers of possessed air weapon systems a national air force could be reasonably expected to employ in identifiable classes of combat operations at given points in time (force propagation potential).

A crucial challenge is the identification of attributes and supporting variables which most comprehensively but efficiently capture essential combat related capabilities. The two main analytical branches described above must be supported by a network of functional subcomponents. In defining these second level focal points, an insensitivity to the texture of the subject and the operative relationships between its parts can be debilitating. The omission of elemental attributes can undermine a model's relevance as was noted in the previous chapter. Consequently, variables must be selected with a keen eye toward the technical complexities of the phenomena they seek to describe. As one research guide admonishes, 'good, basic knowledge' of the subject area is a mandatory prerequisite.[2]

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1 See Blalock, *Social Statistics*, p. 7.

2 Manheim and Rich, *Empirical Political Analysis*, p.235.

3.1.2 Air Weapon Systems Subcomponents and Attributes

With this injunction in mind, the air weapon system subcomponents displayed at the second level in Figure 3.1 are offered as an intermediate framework to guide the evolution of this inquiry. The listed subcomponents are believed to define the predominant non-human elements which comprise an air weapon system.[3] Looking to the left side of the second row in Figure 3.1, the first subcomponent is concerned with the combat potential inherent in the airframe itself. The term airframe will refer in this study to a basic aircraft, less avionics, target acquisition, and weapons systems. The next subcomponent addresses target acquisition and combat-significant avionics systems, while the third is comprised of aerial weapons.[4] Defining the last two subcomponents distinct from the airframe provides an added bonus. Since few target acquistion systems and even fewer weapons are airframe unique, their segregation at this juncture allows the construction of individuallly tailored air weapon systems configurations during the computation process. The function of the fourth subcomponent is not self-evident. With airframes and their subsystems treated separately, a mechanism is required to meld the potential represented by the subcomponents into a specific weapon system employed in a particular combat role. This relational task is the province of the last of the air weapon system's subcomponents.

At the next rung down the analytical ladder, a basic step is the identifcation of those attributes which define the relative performance potential of a weapon system subcomponent. Several air combat oriented publications and studies suggest a variety of candidates. The most operationally relevant of these were flagged as key subcomponent performance attributes.

> *Airframe.* A USAF Tactical Air Command Fighter Weapons' School manual pinpointed two attributes essential to airframe performance: speed and maneuverability. Gunston and Spick's *Modern Air Combat* suggested a third: combat persistence or endurance. The fourth, vulnerability to engagement, was derived from discrete concepts found within these two documents and the TASC study.[5]
>
> *Target Acquisition and Avionics Systems.* Isolating attributes for this subcomponent is made somewhat nebulous by the variety and different purposes of the systems involved. However, two generic attributes appear common: the performance capacity of the system measured on whatever scale is germane and the system's vulnerability to degradation or incapacitiation.

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3 This structure draws heavily on ideas outlined in The Analytic Sciences Corporation's TASCFORM-AIR model and on notes pertaining to the calculation of measures of air combat merit prepared by operations analysts at Northrop Corporation's Aircraft Division.

4 For the purposes of this study, avionics will be limited to navigation systems, fire control computers, and head-up displays. The aerial weapons category includes guns, air-to-air missiles and air-to-ground ordnance.

5 See USAF Fighter Weapons School, *Basic Aerodynamics*, pp.3-20 to 3-22; Gunston and Spick, *Modern Air Combat*, pp.186-193; and The Analytic Sciences Corporation, *The TASCFORM Methodology*, pp.2-14 to 2-15.

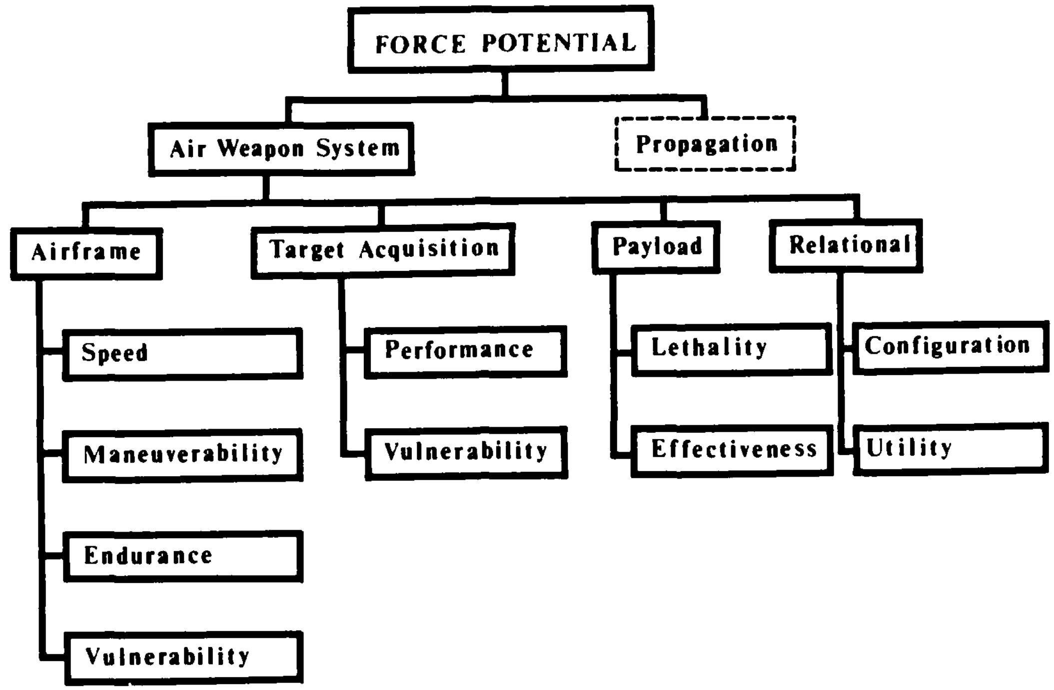

Figure 3.1: An Analytical Typology: Air Weapon System Component

Aerial Weapons. Again, the disparate natures of the systems results in the designation of generic attributes which are a bit vague but which capture the essential combat qualities of a weapon: its lethality and its effectiveness in overcoming countermeasures.

Relational Factors. This subcomponent encompasses two attributes. First, subsystems need to be related in time and space. Second, they must be related in terms of their proportional contribution to mission output. These two attributes are referred to as configuration and relative utility respectively

3.1.3 Force Propagation Subcomponents and Attributes

The assembly of a family of attributes which credibly define the boundaries to realization of combat potential for each nation over time is a daunting task. Authoritative military and academic literature leaves no doubt that a nation's ability to support and operate combat weapons systems is a critical deter-

minant of military effectiveness.[6] Former Israeli Air Force Chief of Staff Ezer Weizman emphatically stated that these largely human factors, '. . .will decide the fate of war, of all wars. Not the Mirage or any other plane. . .'[7] While this point might be somewhat overstated, there is no arguing with its essence. Unfortunately, the individual and national variables which define such attributes as leadership, technical acuity, planning insight, and operator proficiency are virtually impervious to operationalization in the aggregate.[8] Heroic attempts have been made to isolate the variables associated with national support potential and operator proficiency.[9] However, a thorough review of the suggested methodologies substantiated that they involved collection of information concerning variables which would greatly exceed the resources of this research effort (e.g., aircrew training and continuation flying hours) or surrogate variables whose relationships to the attributes they were stipulated to represent were tenuous.

As an additional consideration, the measurement techniques suggested by most researchers who have attacked this problem focus on those variables which might conceivably capture some portion of a nation's 'microcompetance' to operate and employ weapons systems. No systematic measure of the equally important attribute of the 'macrocompetance' required to organize and employ the weapons is available. A review of three decades of Israeli air victories in the Middle East suggests that the latter is just as important as the former. For these reasons, the effort to derive national measures of merit for operator proficiency or employment effectiveness was deferred to other researchers. Indeed, it is probable that regional experts can subjectively factor in these considerations with greater validity and efficiency than can be generated by a fixed computational scheme.[10]

As a result of this determination, the evaluation of employment factors in this study is limited to those factors which inscribe an outer boundary on a nation's capability to generate its combat forces. With this caveat, the analytical typology dealing with force propagation is displayed in Figure 3.2. Obviously, the inventory of air weapon systems possessed by a force is a necessary point of departure. This gross total must be further elaborated by a term which reflects their likely allocation to given combat roles. To complete the picture, some measure of a nation's cumulative potential to employ the opera-

6 Excellent discussions of realistic constraints imposed by operational and support capabilities can be found in Pascal et al, *Men and Arms in the Middle East*; de Leon, *The Peacetime Evalutation of the Pilot Skill Factor in Air-to-Air Combat*; Kemp, *Arms and Security*; and DuPuy, 'Measuring Combat Effectiveness'; among others.

7 Quoted in Lambeth, *Moscow's Lessons from the 1982 Lebanon Air War*, p.31. Ironically, Israel has consistently pressed for the subsidized acqusition of the most advanced American systems and energetically contested the Arab acqusition of the same or lesser capabilities.

8 See, for instance, Benjamin Lambeth's comments in 'Pitfalls in Fighter Force Planning', p.16.

9 See in particular Pascal et al, op.cit., Timperlake and Leveen, *A Methodology for Estimating Comparative Aircrew Proficiency*, and Leveen and Vogt, *A Methodology for Assessing Groundcrew Proficiency*.

10 This is an adaptation of the injunction credited to Alain Einthoven. The point is to render unto computers the things that are computers and to judgment the things that are judgments. Quoted in USGAO, *Models, Data, and War*, p.73.

tionally available inventory in the combat roles to which they have been allocated must be derived. The ability to generate assets is the product of three attributes: the proportion of the force available for combat operations, the maintenance support they require, and the maintenance resources on-hand to service them.[11]

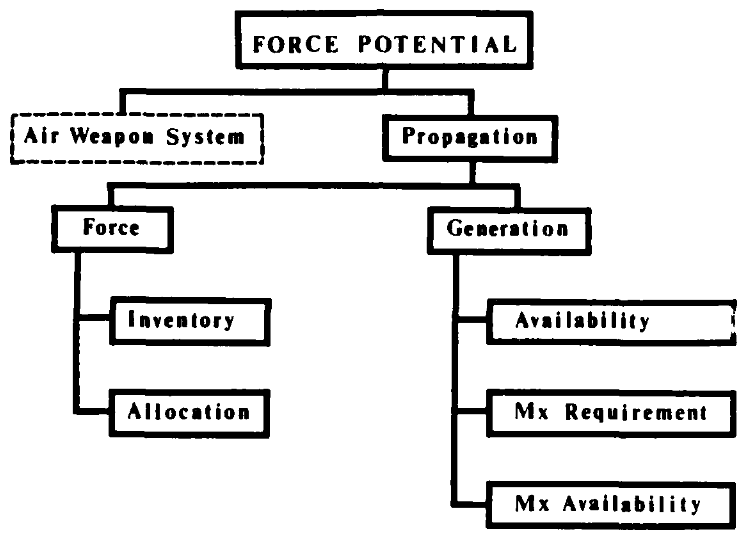

Figure 3.2: An Analytical Typology: Force Propagation Component

Regarding Figure 3.1 and Figure 3.2 together, the attributes identified at the third level of the hierarchical structure represent the basic blocks with which a force level combat assessment can be built. As such, they constitute a map to guide the search for potential capability measurement variables. The numbers of variables describing a particular attribute might be as few as one or as many as ten or more. Their selection is a function of the nature of the attribute, the relevant observations which pertain to it, and the availability of descriptive data.

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11 The abbreviation 'Mx' is used as a shorthand term to describe maintenance.

3.2 Variable Selection Guidelines

Even within these structured confines, the plethora of candidate variables far outstrips processing or intellectual resources. Consequently, the explanatory power of possibly pertinent variables has to be screened finely to extract the minimum number which explain the maximum significant variance in air weapon system and national performance potential.[12] The number of variables linked to an attribute should not be so harshly pruned that comprehensive evaluation becomes illusory. On the other hand, redundant variables which capture the same essential facet of an attribute need to be eliminated to avoid analytical distortion. The more definitive the scale on which a variable is measured, the more precise are the results which can be obtained from its analysis. Consequently, ratio or interval scaled variables are preferrable to those valued on nominal or ordinal scales. However, ratio or interval level measures are not always applicable to or available for key variables. While nominally described variables are not fully amenable to some statistical processes, they should be included in the analysis if no legitimate alternative exists. Capturing the effect of relevant attributes is more critical than adulterating the substance of the problem to accommodate sophisticated statistical techniques.

A final temptation to be eschewed is the substitution of accessible 'surrogates' for qualities which are not directly observable or or easily quantifiable. The use of surrogates is not in itself an unsound practice; but each surrogate must be subjected to rigorous scrutiny before inclusion. The incorporation of surrogate variables which are only minimally or coincidentally related to the qualities they are designated to represent cannot help but distort the resulting analysis from a substantive standpoint, often lethally.

In the same vein, the creation of composite or index variables stipulated to stand in for a more complex and mathmatically indescribable characteristic must be treated cautiously. Indices frequently convey meaningful performance related information unobtainable through any single component measure. In the realm of aircraft, thrust-to-weight ratio, wing loading, and wing aspect ratio are all widely recognized as legitimate indicators of energy maneuverability, turning capability, and relative lift respectively. However, indices are legitimate only when their components have a functional impact on the characteristic being represented and their combinational mode reflects an engineering or operational reality. A poorly chosen surrogate or an invalidly constructed composite variable not only can miss the mark, it can lead the analysis astray.

In consonance with the preceding, some basic ground rules are offerred to govern the identification of study variables.

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12 This principle is often referred to as 'parsimony' and is commonly acclaimed as one of the key attributes of any higher-order research effort. See, for instance, Manheim and Rich, op cit., p.353.

- A list of candidate variable supporting the analytical structure described above should provide broadest practicable explanation of the sources of variance implicit to each attribute.
- Variable lists should be culled to the minimum required to explain combat relevant variance, eliminating redundant measures.
- Comprehensive attribute representation should overrule concerns for parsimony.
- Variables should be selected which represent the highest level measurement of the attribute being portrayed but should not be eliminated if only measurable at a lower level.
- Surrogate variables should be used only as a last resort, and composite variables only when functional or operational precedents had been established.

3.2.1 Variable Selection Process

3.2.1.1 Air Weapon Systems

A list of candidate system variables was compiled in 'shopping list' fashion, relying on attributes featured in publications such as *Jane's All the World's Aircraft*, USAF Fighter Weapons School's *Basic Aerodynamics*, and *Modern Air Combat*. Other variables were gleaned from periodicals such as *Aviation Week and Space Technology* and *Air Force Magazine*. Finally, variables considered in other military analyses were appended to the list if not previously included.[13] As a final test of inclusiveness, the variable list was submitted to a panel of three fighter pilots and one intelligence expert for review, and their revisions incorporated.

The initial 300 variable list was exhaustive but unweildly and inappropriate for further action without aggressive winnowing. It is immediately evident that collecting data on this number of variables is overwhelming, even in the unlikely circumstance that the requisite data were available in unclassified sources. Some categories of of variables had to be simplified to permit concentration on the most salient combat related attributes. Avionics systems with important combat performance implications are treated generically as nominally scored single variables. For instance, the variable 'NAVCAT' cites navigation system type, and the presence of head-up displays and integrated fire control systems is captured in nominal variables. The profusion of air to ground weapons systems and the multiplicity of associated characteristics make them a particularly unweildly variable group.[14] Nonetheless, categorical variables are retained to indicate an aircraft's precision guided munitions capability and type, partially accounting for advanced weapons capacity. Finally, the question of assessing air weapon ground support requirements through

13 For instance, LeGrow offers a thorough discussion of some performance variables and the dimensions they capture, while TASCFORM's charts and equations give a good overview of the attributes and their inter-relationships. See also Cordesman, *Jordanian Arms* and *The Gulf and the Search for Security*

14 It is reassuring to note that The Analytic Science Corporation arrived at the same conclusion concerning air to ground weapons in their quite exhaustive study.

analysis of a family of maintenance variables was deferred. Instead, the single variable, Man-Maintenance Hours Per Flying Hour (MMH/FH), recommended by Epstein as the best single indicator of support complexity, was introduced.[15]

3.2.1.2 Airframes

Application of the above considerations reduces the number of variables to be considered to manageable proportions. In addition, the structure was modified slightly to facilitate automated manipulation and statistical processing.[16] The initial complement of variables intended to portray the attributes of an airframe itself is displayed in Table 3.1 The variables annotated with asterisks (*) are measured on a nominal scale. Definitions of the variables follow the table. A complete file description is in Appendix A.

Table 3.1: Airframe Variables

Aircraft	Role
Wing Span	Wing Surface
Wing Aspect Ratio	Combat Weight
Empty Weight	Maximum Weight
Combat Wing Loading	Internal Fuel
Fuel Fraction	Combat G Limit
Maximum Thrust	Thrust-to-Weight Ratio
Variable Wing*	Variable Camber*
Maximum Airspeed FL360	Specific Energy At Altitude
Maximum Airspeed SL	Specific Energy SL
Rate of Climb SL	Stall Speed
Rate of Turn	Specific Excess Power
Service Ceiling	Intercept Radius
Attack Radius	Combat Range
Maximum Ordnance	Weapons Stations
Internal Guns	Gun Rounds

Aircraft. The name and variant of the aircraft.

Role. Defines the aircraft system type (e.g., fighter-interceptor, bomber-ground attack). Not to be confused with nationally determined employment codes which are associated with the inventory subcomponent.

Wing Span. Distance from wing-tip to wing-tip, not considering tip mounted stores.

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15 Epstein, *Measuring Military Power*, p.19.

16 The *Statistical Package for the Social Sciences*, release Ten (SPSSX) was used for the creation of data files and all statistical and computational processing. A micro-computer based set of files and procedures is currently under development.

Wing Surface.
Total wing surface area, not considering tip mounted stores.

Wing Aspect Ratio.
Describes the planform shape of a wing, a factor which affects the wing's lift coefficient.

Combat Weight.
A weight calculation which defines the likely gross weight of an aircraft when engaged in combat (as opposed to maximum takeoff weight).

Empty Weight.
The weight of an aircraft fully equipped less fuel and stores.

Maximum Weight.
The maximum takeoff weight of an aircraft fully fueled and loaded with stores.

Internal Fuel. The internal fuel capacity of an aircraft measured by weight.

Wing Loading.
The ratio of combat gross weight to wing surface area. Indicates the relative turning performance of an aircraft, with an inverse relationship between the two.

Fuel Fraction.
Compares the internal fuel weight of an aircraft to its combat gross weight as an indicator of combat persistence.

Combat G Limit.
The maximum centrifugal force, expressed in terms of acceleration of gravity, an aircraft is designed to withstand in maneuvering combat.

Maximum Thrust.
The maximum 'wet' (with afterburner) thrust which an aircraft's powerplant can generate at sea level.

Variable Wing.
Notes the presence of a variable geometry or 'swing' wing.

Variable Camber.
Notes the presence of devices such as leading edge slats or maneuvering flaps which change the camber of wings in flight, thereby improving turning performance.

Thrust-to-Weight Ratio
Compares the combat gross weight of an aircraft to its installed thrust as an indicator of its ability to accelerate and sustain turn rates.

Maximum Airspeed FL360.
Measures maximum airspeed in a high altitude profile. This altitude (36,000 feet) was selected as it represents the high end of a likely combat envelope under most scenarios.

Maximum Airspeed SL.
Measures maximum airspeed at sea level. Sea level was selected as representative of the low end of the combat envelope, at which aircraft might well have significantly different speed capability than at higher altitudes, thus giving a better perspective of 'useful speed'.

Specific Energy Alt.
A measurement of the total mechanical energy (kinetic plus potential) of an aircraft at its maximum air speed and service ceiling.

Specific Energy SL.
As above, except measured at sea level.

Stall Speed. Speed at which the aircraft's drag exceeds its aerodynamic lift in level flight.

Rate of Turn. The maximum instantaneous level turn performance an aircraft can achieve at sea level in clean configuration.

Specific Excess Power.
Measures an aircraft's ability to change its energy state by accelerating. Calculated at a particular condition of flight (10,000 ft, Mach .9, level flight in this instance).

Service Ceiling.
Altitude above which aircraft is incapable of further acceleration.

Intercept Radius.
Maximum radius at which a normally air-to-air mission configured aircraft can conduct a sub-sonic area intercept mission.

Attack Radius.
Maximum radius at which a normally air-to-ground mission configured aircraft flying a hi-lo-lo-hi profile can attack a target.

Combat Range.
Maximum range at which an aircraft can conduct its primary combat mission.

Maximum Ordnance.
Maximum weight of air-to-ground ordnance which the aircraft can carry.

Weapons Stations.
Number of weapons stations available for air-to-ground ordnance.

Internal Guns.
Number of guns mounted internally to the aircraft.

Gun Rounds. Number of rounds of ammunition normally carried for the internal gun(s).

3.2.1.3 Target Acquisition Systems

The next data set is comprised of performance variables associated with target acquisition attributes. While it consists of variables measured on both ratio and nominal scales, only the ratio level variables are candidates for statistical manipulation. It is displayed in Table 3.2, with nominally measured variables annotated (*).

Name. Most frequently, the alpha-numeric designator assigned to the system. In the case of U.S. systems, the leading 'AN' portion of the designator has been dropped. For those systems for which the designator is not published in open sources, such as the SU-27 Flanker, a descriptive entry (i.e., 'FLANRAD') is used.

Table 3.2: Target Acquisition System Variables

Name	Code
Output Power	Coverage
Range-High Target	Range-Low Target
Data Points	Track While Scan*
CW Illumination*	Ground Mapping*
Doppler Beam Sharpening*	ECCM Capability*

Code. A four letter descriptor of system type. The first two letters describe the system's generic category (e.g., 'RA' for radar, 'LA' for laser) and the second two address its primary employment role (e.g., 'AI' for air-intercept, 'GA' for ground-attack).

Output Power. Actual or equivalent power emitted by system.

Coverage. Angular lateral coverage provided by the system, akin to the field of view.

Range-High Target. Maximum range at which a fighter-sized target operating at the same or higher altitude could be detected.

Range-Low Target. Maximum range at which a fighter sized target operating at lower altitude could be detected.

Data Points. The number of relevant information points (such as range, bearing, altitude, airspeed) the system generates concerning the target.

Track While Scan. Ability to continue to scan for potential threats while tracking the highest threat target(s).

CW Illumination. Ability to provide the continuous wave target illumination required to guide semi-active radar homing air to air missiles.

Ground Mapping. Ability to provide radar display of ground environment with sufficient resolution to identify geographic or cultural features.

Doppler Beam Sharpening. Ability to increase resolution of ground map display so that targets or waypoints can be easily identified.

ECCM Capability. Indicator of system's relative resistance to electronic counter measures through features such as side-lobe suppression or frequency agility.

3.2.1.4 Air-to-Air Missiles

The next variable set, outlined in Table 3.3, is comprised of variables associated with air-to-air missiles. As with target acquisition systems, this table lists variables measured on both ratio and nominal scales. Nominally scaled variables are not being considered for statistical processing, although they will eventually be involved in combat potential computations.

Table 3.3: Air to Air Missile Variables

Missile Diameter	Missile Length
Missile Weight	Terminal Guidance Mode*
Maximum Range-Head On	Minimum Range-Head On
Effective Range-Head On	Maximum Range-Tail
Minimum Range-Tail	Effective Range-Tail
Warhead Weight	Fuzing Options
Maximum Speed	G Limit
ECM Susceptibility*	Guidance Score*
Acquisition Mode*	

Missile Diameter.
Diameter of missile's body.

Missile Length.
Length of missile.

Missile Weight.
Gross weight of the missile.

Terminal Guidance Mode.
Method (semi active radar homing, infrared, active radar homing, command guided, etc.) by which missile is guided during its terminal phase.

Maximum Range-Head On.
Maximum range against a target which is converging with the launch platform from the forward hemisphere.

Minimum Range-Head On.
Range from the launch platform within which the missile is ineffective against a target approaching from the forward hemisphere.

Effective Range-Head On.
Range envelope within which the missile is effective against a target approaching from the forward hemisphere.

Maximum Range-Tail.
Maximum range against a receding target.

Minimum Range-Tail.
Range from the launch platform within which the missile is ineffective against a receding target.

Effective Range-Tail.
Range envelope within which the missile is effective against a receding target.

Warhead Weight.
Weight of missile warhead.

Fuzing Options.
The number of fuzing methods available.

Maximum Speed.
Maximum missile speed to burnout.

G Limit. The maximum centrifugal force, expressed in terms gravitational acceleration, the missile can accept; an indicator of maneuverability.

ECM Susceptibility.
A relative measure of the missile guidance system's susceptibility to defeat by electronic combat measures such as flares, chaff, or jamming.

Guidance Score.
An indicator of relative guidance system accurancy.

Acquisition Mode.
Indicates if guidance system is capable of locking-on to a target beyond visual range.

3.2.1.5 Aerial Guns

The final weapon system table, Table 3.4, lists key variables associated with aerial gun systems. All of the variables are measured at the ratio level.

Table 3.4: Aerial Gun Variables

Calibre	Maximum Effective Range
Dispersion	Muzzle Velocity
Rate of Fire	

Calibre. Calibre of gun

Maximum Effective Range.
Maximum range at which projectile maintains sufficient velocity to remain effective.

Dispersion. A measure of relative accuracy which reflects dispersion of rounds around a mean point of impact.

Muzzle Velocity.
Projectile velocity as it exits the gun.

Rate of Fire. Maximum number of rounds which the gun can fire in a minute.

3.2.1.6 Relational Variables

Aircraft Configuration. This set of variables mates the airframe with its subsystems (target acquisition and weapons). In addition, it contains those combat-related performance variables which are not suited to statistical manipulation but which still need to be considered in calculating air combat potential. For ease of manipulation, these are assembled in the configuration file shown in Table 3.5. As was the case previously, variables are defined following the table. Variables involved in mission potential computations are annotated (*), and a formal file description is located in Appendix A.

Table 3.5: Aicraft Configuration Variables

Crew Members*	Air Refueling Capable*
Navigation Category*	Radar Warning Receiver*
Passive ECM*	Active ECM*
Radar System	Other Target Acquisition
Head Up Display*	Stability Augmentation*
Radar Guided AAM	Number Radar AAM*
Infrared Guided AAM	Number Infrared AAM*
Gun System	PGM Capable*
Release Point Computer*	Maintenance Hours Per Flying Hour*
Production Country	

Crew Members.
Number of aircrew members normally assigned.

Air Refueling Capable.
Indicates if aircraft is capable of aerial refueling.

Navigation Category.
Identifies most sophisticated category of navigation system fitted to the aircraft.

Radar Warning Receiver.
Indicates presence of an electronic warfare threat receiver (detector).

Passive ECM.
Indicates capability to dispense non-intrusive electronic combat expendables such as flares or chaff.

Active ECM. Indicates equippage with internal or external radar jamming or deception systems.

Radar System.
Identifies the target acquisition radar (air intercept, air-to-ground, or multi-mode) installed in the aircraft.

Other Target Acquisition.
Identifies additional target acquisition systems (infra-red search track, laser, forward-looking infrared) installed in or on the aircraft.

Head Up Display.
Identifies the presence of a system which displays operational and combat related data on a combining glass at eye level.

Stability Augmentation.
Measures to increase platform stability during air-to-ground weapon delivery.

Radar Guided AAM.
Identifies the radar guided air-to-air missile normally carried on the aircraft.

Number Radar AAM.
The number of radar guided AAMs normally carried.

Infrared Guided AAM.
Identifies the infrared guided AAM normally carried by the aircraft.

Number Infrared AAM.
The number of infrared AAMs normally carried by the aircraft.

Gun System. Identifies the aerial gun normally mounted internally.

PGM Capable.
Indicates aircraft potential to deliver precision guided air-to-ground munitions.

Release Point Computer.
Indicates presence of a computer which provides a CCIP/CCRP type solution for release of bombs.

Production Country.
A code which describes the initial country of production for the air weapon system. The singular exception are a few indicators which credit a host country such as Israel with making such drastic modifications to the aircraft that it is drastically different from its antecedant.

Maintenance Hours Per Flying Hour.
An estimate of the man-maintenance hours required to support one flying hour by a particular system.

Relative Utility. The problem of identifying variables which relate system and subsystem attributes to mission output potential presents a thorny challenge. No definitive methodology entirely congruous with the objectives of this project could be identified, although the TASCFORM model embodies many applicable concepts. Applying TASC's concepts in conjunction with advice from air operations experts, those junctures were isolated at which key combat related attributes were joined, building from the subcomponent to the full air weapon system level. For example, if an airframe possesses attributes categorized as speed, maneuverability, and endurance, these would interact in varying proportions to contribute to combat success in particular missions. At a higher level, the summed attributes of the airframe would interact with the summed attributes of the the target acquisition system and payload in proportions the values of which would be differentiated by mission. Employing this 'building block' approach, the list of variables shown in Table 3.6 designates the juncture points. The values for each variable represent the

relative utility of a given attribute at a given juncture. To eliminate redundancy, each entry actually represents four variables, one for each of the projected combat roles: air defense, air superiority, interdiction, and close air support.[17] The breaks in the table represent the progression of 'blocks' building to full air weapon system potential.[18]

Table 3.6: Relative Utility Value Variables

Airframe Component	
Airspeed Utility	Maneuverability Utility
Combat Endurance Utility	
Payload Component	
Infrared AAM Utility	Radar AAM Utility
Gun Utility	Unguided Ordnance Utility
Guided Ordnance Utility	
Target Acquisition Component	
Visual System Utility	Radar System Utility
Secondary System Utility	
Engagement Vulnerability Component	
Airspeed Utility	Maneuverability Utility
ECM Utility	Signature Utility
Air Weapon System	
Airframe Utility	Acquisition System Utility
Payload Utility	

3.2.2 Force Propagation Variables

Two alternative variable definition strategies were considered for assembling inventory data. Much of the arms transfer literature concentrates on describing and evaluating the flow of weapons and associated capabilities. While this approach has its merits, evaluating the combat potential which results from the transfers involves the broader task of fixing those capabilities in the context of a national and regional force structure. Additionally, the task of assembling a unfied body of reliable data on the flow of arms is fraught with uncertainty. The potential for gleaning accurate data on major systems once they have been introduced into an inventory is more promising than attempting to capture them 'in the pipeline'.

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17 The formal description for this file is not presented in Appendix A, since the file is actually composed of 76 discrete variables cryptically identified. The presentation in Table 3.6 should convey sufficent information to grasp its content adequately.

18 The 'Vulnerability Component' constitutes a factor which depreciates the combat potential of the entire air weapon system. As such, the relative values for its subcomponents need to be identified, but it has by definition a relative utility of unity

3.2.2.1 Inventory

Consequently, an inventory approach was selected. To preserve the capability to track combat potential back to the arms transfer source, the country of production variable in the system data sets could be employed. An additional consideration is the identification of the likely employment of a weapons system by a given country. Consequently, a variable stipulating employment code is necessary. Table 3.7 lists the inventory related variables on which data would be collected. While the formal inventory file, described in Appendix A, includes information at the weapon system level only, a separate listing of sub-systems available to a given country was prepared off-line for entry as variable values in the system configuration file.

Table 3.7: Inventory Variables

```
Country Code
Weapon System Name
Employment Code
Weapon System Inventory
Operational Availability Rate
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Country Code.
A two letter code, corresponding to DoD standard usage, which identifies the country possessing the weapon system.

Weapon System Name.
The name of the air weapon system. Identical to aircraft name.

Employment Code.
An alpha-numeric code which identifies the likely combat role of the unit to which an air weapon system is assigned (e.g., 'FGA' for fighter-ground attack, 'FMR' for fighter-multi-role).

Weapon System Inventory.
The number of a particular aircraft possessed by a country in a given year.

Operationally Available Rate.
The estimated fraction of possessed aircraft which would be available for operational employment.

3.2.2.2 Employment

As noted earlier, this study will limit its employment purview to those quantifiable attributes which impinge directly on a national air force's capability to generate a multiple (sortie rate) of the combat potential embodied in its individual weapon systems. Joshua Epstein convincingly demonstrated the viability of

this concept in evaluating the Soviet air threat to Europe. Epstein contends that by weighing the amount of maintenance required by an inventory of aircraft against the amount of maintenance available, the analyst can set a sortie generation boundary.[19] While Epstein acknowledges the important roles personnel quality, doctrine, and organization play in determining actual rates within an outer sortie generation boundary, he asserts that calculating the boundary at least defines the 'worst case' even when all the other variables are assumed to be equal. Operationalizing the problem requires that the researcher collect data which describes the maintenance requirement imposed by each aircraft, the maintenance resources available to the national air force, and the employment scenarios in which the force will be employed.[20]

To inject a greater differentiation and realism into the problem, additional qualitative variables will be considered on an experimental basis. One study by The Analytic Sciences Corporation concluded that the quality of ground support is the product of the motivation and technical acuity of the servicing groundcrews. The technical acuity dimension is measured by assessing relative educational levels and the effects of exposure to technical systems like automobiles and telephones. These measurements are modified by a term which estimates the range of the population to which the average technical value would apply and accounts for the influence of foreign advisors. Motivation is purportedly captured by scaling nations on a psychologically oriented matrix which assesses relative adherence to the 'active mastery' theme inherent in the 'Protestant Ethic'.[21] While this approach might well be valid, the underlying psychological principles and assignment criteria are too speculative to be applied here. Consequently, variables suggesting motivation were drawn from two other studies which addressed an analogous subject.[22] These include the number of armed forces per thousand, military expenditures per capita, and military expenditures per GNP. The latter two variables also provide some indication of the relative investment in support resources being made by the country concerned. The resulting employment variable set is depicted in Table 3.8. Only the top two quantitative variables will be included in the baseline methodology. The remainding qualitative variables will be employed for experimental purposes only and are by no means definitive.

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19 Another study focused on Europe contends that, in the European environment at least, the availability of pilots might be an even more potent predictor of sortie generation boundaries. See Alberts, *Deterrence in the 1980's: Part II, The Role of Conventional Air Power*, p.32. This limitation will apply even more stringently in most Third World countries. Unfortunately, its consideration was deferred because of the predictable lack of aircrew information at the unclassified level. However, it is a factor which might be reintroduced if sufficient information became available.

20 Discussions with Northrop Corporation analysts revealed that they include estimates of sortie duration by mission type, the length of the flying day, and the length of the maintenance day in their sortie generation computation. While the methodology they employ is considerably more sophisticated than the one contemplated here and is anchored at the weapon system rather than force level, their approach is generally consistent with Epstein's.

21 See Leveen and Vogt, *A Methodology for Assessing Groundcrew Proficiency*, pp.2-1 to 2-34.

22 See Timperlake and Leveen, *A Methodology for Estimating Comparative Aircrew Proficiency*, p.3-11, and Pascal et al, op.cit., p.38.

Table 3.8: Sortie Generation Variables

Maintenance Hours Required
Maintenance Hours Available
Literacy Rate
Percentage Eligible in Secondary School
Armed Forces Per Thousand
Military Expenditures Per Capita
Military Expenditures Per GNP
Military Expenditures Per Government Expenditures

3.3 Summary

This section has outlined a methodological structure which will be employed to channel the collection of data relevant to the assessment of the combat potential of Middle Eastern air forces as a function of their acquisition of air weapon systems. The overall problem was decomposed into two components: one which addresses the combat potential inherent in the systems themselves and a second which considers the force propagation potential of the operating nation. Each component is further segmented into a hierarchy of subcomponents, attributes, and the variables which describe them. The structure created in this chapter in essence constitutes a data collection plan, the implementation of which will be discussed in Chapter 4.

Chapter 4
DATA COLLECTION

4.1 Collection Boundaries.

Since the goal of this study is to evolve a workable methodology rather than to provide universally applicable substantive solutions, it was necessary from the outset to draw some boundaries for data collection and analytical focus. The regional boundary (Middle East) has already been drawn, but some additional limitations need to be imposed. Though the definition of these boundaries restricts the playing field somewhat, the essentials of the game are preserved.

4.1.1 Temporal.

Only those combat aircraft employed in the region during the last decade or which might reasonably be introduced into it during the next will be considered. This temporal limit might appear to conflict with the injunction laid down by other researchers to construct evaluation schemes valid over time, with data bases looking back to World War II vintage aircraft. Historical merit aside, such a broad approach seems unduly effusive in a scheme geared primarily to forward looking evaluation.

4.1.2 Functional.

A further limitation is to concentrate on those aircraft involved in primary combat roles. Consequently systems such as the E3A/AWACS, E2C/Hawkeye, reconnaissance platforms, and airborne tankers are not included, although they support combat operations. Similarly, aircraft whose sole function is aircrew primary training are not included, but those advanced or conversion trainers which could be easily shifted to a combat role are.[1] Finally, rotary-wing combatants are not addressed in this initial study, although they promise to play an increasingly significant role in Mideast combat. These restrictions on systems consideration limit the field somewhat severely and regrettably exclude some important support aspects of combat potential estimation. Nonetheless, the inclusion of over 120 combat aircraft makes it a representative and viable data set.

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1 Some reconnaissance and training versions of combatant aircraft were included in the initial data base compilation and analysis phases and are displayed in the orders of battle. However, no combat potential scores were computed for them.

4.1.3 Informational.

A final note on limitations is intended primarily for U.S. Government users. The data included in the various study data bases are taken strictly from open source, unclassified materials. As a result, individual data values might be at odds with those reflected in classified documents. Additionally, the author was, at times, required to rely on an estimative process to arrive at data values he recognizes are specified more precisely in authoritative classified data bases. This limitation was imposed for two reasons. Large-scale automated statistical processing could not be conducted in a classified environment at the research institution. Also, a classified product would not be widely available for the critical review and comment of academic researchers. The unclassified data, although less precise, satisfactorily describe key variances, and the penalty paid in accuracy by using them will be outweighed by the value of critical comments from the academic community.

4.2 Some Collection Principles.

4.2.1 Leveling the Field.

The research and intelligence communities are often captivated by the illusion that there is somewhere a number which reflects 'truth' with a capital 'T'. In reviewing the many publications and articles offering information on weapon system characteristics and inventories, one is struck by a multiplicity of contending 'truths'. There is a profusion of data on many variables, but a substantial portion is contradictory and of undefined derivation. The producer claims the ground attack radius of an F-20A is 550NM, while other sources list it as 455NM and 595NM respectively. One very well informed author alternatively notes the AN/APG-66A (now termed AN/APG-68) radar has a maximum target acquisition range against a low altitude target of 47NM in one book and 38NM in another. Defense related literature is replete with such examples. In the absence of a definitive classified source, what rule of thumb can be applied to discriminating among competing 'truths'?

4.2.1.1 Conflicting Evidence

Along with simple error, deviations in data values appear to proceed primarily from two sources. Performance characteristics are observed under a variety of conditions. Factors such as weapons load, mission profiles, estimates of combat duration and loiter time all contribute to the measurement of a variable like ground attack radius. Even seemingly straightforward characteristics (e.g., combat weight, thrust-to-weight ratio, wing loading) can be calculated from different but often unspecified bases.[2] Except in classified technical publications, it is rare that these conditions are cited. Even when they are, the conditions

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[2] Analogous considerations apply to other types of data observations as well. Is an arms transfer counted upon initiation (SIPRI) or upon consummation (ACDA)?

are invariably unique to a particular case or to a small family of cases. Consequently, it is virtually impossible to identify values for a variable down an entire list of cases which were similarly observed.[3] The second source of deviation stems from the difference between design goals and realized operational performance. With newer systems especially, the lack of an established performance history appears to leave the field open to 'best case' analysis and some measure of speculation.

4.2.1.2 Resolving Contradictions

There is no neat method for unravelling the resultant web of uncertainty, but its grasp can be loosened if the collector recognizes the sources of variation and attempts to level the playing field. In this study, no one source was viewed as 'gospel'. Values for a system or inventory variable were collected from several sources, along with information on measurement criteria when presented. When values conflicted, measurement conditions were examined if available or estimated if not. The value was selected which most closely approximated the weapons and fuel loads and operational settings deemed likely in regional combat. Even when data did not conflict, observation conditions were reviewed or estimated to assess their correspondance to the regional employment environment. If deviations appeared substantial, values were adjusted accordingly. Once the basic data had been sifted, mathmatically derived values for variables such as combat weight, wing aspect ratio, thrust-to-weight ratio, fuel fraction, and wing loading were recomputed using the formulae described below. This procedure generated a set of data bases in which the sources of deviation had been minimized and in which the biases, if any, were at least consistent.

4.2.2 Filling Gaps

4.2.2.1 All the Numbers

Missing data are the bane of the quantitative researcher. Missing data adulterate statistical results and cast suspicion on final values computed for each case. As Joshua Epstein notes, the researcher has two options when confronted with missing data.[4]

> First, one can stop, throw in the towel, and regress to bean counting. Or, one can proceed like a rational animal: by fighting off the conditioned response that perfect measurements are necessary to make a reasoned judgment on bounds; by drawing the most intelligent inferences one can from the data that are available; and by varying one's assumptions so that the consequences of irreducible uncertainty may be gauged.

These principles were, of necessity, applied liberally in the research at hand.

After initial data collection and review, missing data dominated some variable columns and affected all. Across the spectrum of variables and cases, missing data represented over 20% of the observations, with higher concentrations in certain key variables and sets of cases. Some of the variables for which

3 There is a horizontal dimension to this dilemma as well. Have the values for unique but related variable for the same system been measured under the same circumstances?

4 Epstein, *Measuring Military Power*, pp.145-146.

more than 50% of the data were missing were dropped in the belief that their explanatory power was negligible or was captured just as well or better by other variables (e.g., combat range, stall speed). However, there were no suitable sustitutes for the explanatory power represented by others such as specific excess power, instantaneous rate of turn, and combat radii. From a case perspective, data were most often missing for Soviet and some European produced aircraft, a variety of target acquisition systems, and countries with Soviet dominated inventories. Whether missing data represented a major portion of the observations on a variable or were limited to just a few, the task was the same - to fill in the blanks through 'intelligent inference'.

4.2.2.2 Analogous Comparison

The inferential process moved through three phases in ascending order of complexity and descending order of certitude. First, cases with missing data were reviewed to suggest analogous cases for which data on a given variable might be available. This procedure was particularly fruitful in filling in gaps in observations on individual models of a 'family' of aircraft. For instance, if the service ceiling for the MiG-23B were cited in an authoritative source, but none were listed for the MIG-23E, the value for the MiG-23B was assumed to apply to both models. In a slightly broader extension, a 'signature' characteristic of a generation of equipment from the same producer was assigned to cases missing that value. For example, aircraft fielded by Dassault-Breguet during the 1970's on which Combat 'G' Limit data were available all showed the same value (7.33). That value was extended to aircraft from the same producer on which definitive information was not available.[5]

4.2.2.3 Regression Analysis.

The relatively innocuous analogical process was successful in reducing the body of missing data considerably, but some troublesome although scattered gaps in key variable observations remained, notably those pertaining to combat radii and maximum speeds. A statistical inferential tool, regression analysis, was employed to fill these gaps, with the results modified by expert judgment. Pearson correlation coefficients were inspected to identify variables pairs which displayed strong statistical affinity. Those pairs which did not also intersect functionally (statistical artifacts) were discarded. The remainder were plotted to determine the statistical significance of their relationship and to ascertain if the relationship were distorted by extreme values (outliers). In the penultimate step, the variable pairs were subjected to regression analysis to define the predictive potential of one to the value of the other and to derive suitable prediction equations.[6] Finally, the regression equations were employed to predict dependent values for all cases, and the

5 There is always a danger of overlooking a differentiating factor, however. F-15A/B's had a 'G' Limit of 7.33, but sensor changes in the C/D model permitted an increase in the placard limit to 9.0.

6 Some tests were also conducted using two, three, and four predictor variables in multiple regression equations. This technique is arguably more powerful than the variable pair approach and bears further

results were compared to those cases with known values on the dependent variable to judge the equation's efficacy.

To illustrate the process, the value for sub-sonic area intercept was missing for 21 fighters. One possible variable from which the unknowns could be predicted was ground attack radius. In those cases in which values for both variables were known, they showed a positive correlation (r) of 0.88037 and an R^2 of 0.77505, suggesting good explanatory potential. A scattergram reinforced the picture of a strong positive correlation not unduly influenced by extreme or outlying cases and indicated the variables would display a siginifcant positive relationship in all but one of 10,000 cases (F = .0000). A regression problem with air intercept radius as the criterion (dependent) variable and ground attack radius as the predictor (independent) variable was formulated. The results are depicted in Table 4.1

Table 4.1: Predicting Air Intercept Radius

Ground Attack Radius as a Predictor

Multiple R	.88037	F	=75.80131
R Square	.77505	Signif F =	.0000
Adjusted R Square	.76483		
Standard Error	54.67714		

Variables in the Equation

Variable	B	SE B	BETA	T	SIG T
Ground Atk Rad	.78994	.09073	.88037	8.706	.0000
(Constant)	232.49856	39.61341		5.869	.0000

A solution for the unknown value can be derived by substituting the known value and data from the regression equation into the equation for a straight line: $a = by + k$, where (in this case):

a = Air intercept radius

b = Slope of the regression line

y = Value for ground attack radius

k = Value of the constant (intercept point)

The result of the computation is a predicted value for air intercept radius which, on the average, should fall within plus or minus 55NM (the standard error) of the actual value. When the equation was applied to all cases, and predicted compared to known values, predicted and actual values correlated closely in the middle of the data set, with error as little two nautical miles. However, the observed error increased exponentially toward the upper and lower extremes, resulting in two predictions (of thirty-eight) that were

exploration.

in excess of 120NM off. The average error was 16%, and the direction of error was almost equally distributed between high (52%) and low (48%) predictions. In light of these observations, the predicted values for the 21 unobserved cases were scrutinized individually and modified or estimated by another method if distortion were suspected. This cautionary note notwithstanding, the regression technique, when tempered with expert judgment, proved a most productive and reliable tool for filling data gaps. In all, over 30 regression equations were developed and employed, closing all but the most persistent voids in the data sets.

4.2.2.4 Estimative Analysis.

Analogy and regression work well as gap fillers when values are missing for a limited number of cases and are not disproportionately concentrated on a particular variable or class of cases. Unfortunately, data on several weapons performance variables, two employment related variables, and one class of inventory variable were almost universally unavailable through open data sources. Careful estimation of values appeared to be the only practicable solution. Estimation in this context does not suggest an arbitrary assignment of values simply to provide grist for subsequent evaluations. To the contrary, care was taken to involve ouside experts and other researchers' techniques in bringing the values as close into line with assumed reality as possible. By definition, the estimation process incorporates a margin of error. Its methods are not rigorously scientific, nor are its results exact. The fact that the element of uncertainty may be transmuted into substantive results does not invalidate the overall assessment technique. In fact, the ultimate combat potential computations are designed in such a manner as to permit the painless replacement of estimated data with actual (or better estimated) values if and when they become available. Those variables or classes of cases for which the bulk of the values were estimated are clearly identified in the following section along with notes on the estimative techniques employed.

4.2.2.5 Expert Review.

In the final analysis, there is no substitute for informed judgment. So, the final data bases were submitted for review to two senior fighter pilots (airframes, configuration, air-to-air missiles, and guns), an experienced weapons system operator (target acquisition systems), and a regional intelligence officer (inventories). While their reviews were necessarily cursory, they did identify a number of values which they knew to be in error or suspected to be out of tolerances. Additionally, all variables were analyzed using univariate statistical techniques to flag values which appeared out of character for the data set. Suspect values were double checked and replaced if warranted. This process brought the data bases to the level of completeness required by an investigation of this type while also purging them of random and systematic error.

4.3 Sources and Methods

4.3.1 General Comments.

The data collection process is, regretably, not nearly as cleanly systematic as the resulting well ordered data bases might suggest, nor are the results necessarily definitive. It is incumbent on the researcher to make the collection process as transparent as practicable so that the user can arrive at his or her own conclusions concerning the information's validity. With this precept in mind, the following paragraphs highlight the primary sources used in compiling the research data bases, identify equations used to calculate derivative values, and provide explanatory notes on the techniques used to estimate values for variables which were largely unobserved. Compiling values for many of the variables was relatively forthright and non-controversial, and the associated explanations self-evident to the vast majority of readers. These will not be addressed individually. Nor will each case in which analogous examples or regression predictions were employed to fill discrete data gaps be discussed. Rather, attention will be focused on those variables and classes of cases considered noteworthy or potentially contentious.

The following subsections are ordered in consonance with the variable grouping scheme outlined in Chapter 3. Primary data sources and mitigating factors are discussed in a lead-in paragraph, followed by specific comments on the derivation of values for those variables which might provoke some question. The full data sets are reproduced in Appendices B through D. All were compiled using SPSSX coding conventions, so some of the descriptive information is relatively cryptic. Full variable names, measurement units, and value descriptions are provided in the formal file description documents in Appendix A.

4.3.2 Airframe Performance Data.

4.3.2.1 Sources

Airframe performance data were culled from numerous publications. Various editions of Jane's *All The World's Aircraft* constituted the primary source, closely followed by Gunston and Spick's *Modern Air Combat*. Other specialized publications such as Cordesman's *Jordanian Arms and the Mideast Military Balance* and *The Gulf and the Search for Strategic Stability*, and the Department of Defense's *Soviet Military Power* were also invaluable. A number of periodicals proved fertile sources, particularly on later model systems. The most prominent of these were *Aviation Week and Space Technology*, *Interavia*, *Armed Forces Journal International*, and *Air Force Magazine*. Last but not least, some information was obtained directly from American, British, and French aircraft producers' literature and informally from numerous of the author's acquaintances who had direct experience with particular systems.

4.3.2.2 Comments

The general principles which were applied in sorting through the data and selecting specific values for entry into the data base were described previously. Some explanatory information on variables of interest is provided below. The aeronautical formulae cited were lifted from one of three documents: the U.S. Air Force Fighter Weapons School Instructional Text, *Basic Aerodynamics*; Gunston and Spick's *Modern Air Combat*; and Legrow's *Measuring Military Capabilities for Military and Political Analysis.*

Aircraft Designator. Because of coding protocols, aircraft names had to be condensed in most instances. The aircraft name is followed by the variant designator. In those instances in which an aircraft has undergone major modification for a particular recipient, an additional letter has been attached to the variant code corresponding to the first letter in the name of the operating nation (e.g., MIRIIIEI for the Israeli modified Mirage IIIE). For Soviet aircraft, the name corresponds to the Soviet designator (e.g., MiG-23). The variant designator is derived from the NATO classification (e.g., B) which is more commonly recognizable than the multi-letter Soviet model designators.

Wing Span and Wing Surface Area. Values were for the most part taken directly from source documents. In the case of variable geometry wing fighters, the values were selected which reflected most likely wing sweep during combat employment.

Wing Aspect Ratio. This measurement was recalculated for each aircraft from data entries for wing span and surface area using the formula: $AR = b^2/S$, where,

AR = Wing Aspect Ratio

b = Wing Span

S = Wing Surface Area.

Combat Weight. Values for all aircraft were recalculated to reflect a likely combat weight. The computation added half the internal fuel weight and the weight of a normal combat weapons load to the aircraft's empty weight. All multi-role fighter weights were computed in the air-to-air role. Weapons weight for air-to-air and multi-role aircraft was derived directly from the weight of the air-to-air missiles identified in the aircraft configuration file. Weapons weight for all air-to-ground fighters was calculated at half of maximum ordnance load and that of bombers at full ordnance load. This technique was used because most fighters will rarely fly with a full complement of air-to-ground ordnance, particularly when range is a compelling consideration, as it would be in most Middle Eastern scenarios.

Combat Wing Loading. Values were computed from file data using the formula: $WL = W/S$, where:

WL = Combat Wing Loading

W = Combat Gross Weight

S = Wing Surface Area.

Fuel Fraction. The weight of internal fuel as a percentage of the clean (without weapons) take-off weight of an aircraft.

Thrust-to-Weight Ratio. The ratio of installed (with afterburner at sea level) thrust to combat gross weight.

Specific Energy at Altitude and at Sea Level. Depicts total aircraft energy (kinetic plus potential) under specified conditions of flight according to the formula: $E_s = h + V^2/2g$, where:

E_s = Specific energy under the given condition

h = Altitude (service ceiling or sea level)

V = Maximum Airspeed at altitude or sea level

g = Force of gravity.

Specific Excess Power. Authoritative values for specific excess power were available in open sources for less than 20% of the aircraft in the data set. The small number offered scant promise for application of the analogical or regression techniques. A less rigorous and less reliable estimative approach was called for. Specific excess power measures an aircraft's relative ability to change its energy state. Thus, it must be measured from a common energy state described in reference to altitude, velocity, and attitude. In deference to available data, these were stipulated as 10,000ft, .9Mach, and 1G respectively. Specific excess power can be calculated by the following equation: $P_s = V(T\text{-}D)/W$, where:

P_s = Specific excess power

V = Velocity (.9 Mach)

T = Maximum thrust available

D = Drag

W = Combat gross weight.

Thrust and weight data were readily available, but information on drag is rarely published in unclassified sources. With expert assistance,[7] drag was 'back-calculated' for those aircraft for which P_s was known and was compared to variables observed for all aircraft. Wing surface area and combat weight appeared to offer the most explanatory promise. With too few observations to conduct a proper regression analysis, several calculations were tested until the equations which most accurately predicted to the known values were isolated. These equations were applied to establish values for drag. P_s was then calculated for all cases. The results were largely satisfactory, although not precise, with one exception. Values for Soviet and earlier generation aircraft were larger than deemed reasonable. This overestimation is believed to result from the fact that the estimates were primarily derived from observations on late-model U.S. aircraft which are generally aerodynamically cleaner than their Soviet counterparts and earlier genera-

7 Colonel Michael Nelson was invaluable in untangling the technical web associated with this and other aeronautical questions and in suggesting alternative approaches to estimative hurdles. Without his help, it is unlikely they would have been cleared.

tion aircraft. That quality was not captured in the estimate. To compensate, estimated P_s values for Soviet aircraft and early generation U.S. and European aircraft were adjusted downward on a case-by-case basis, with a maximum adjustment of 10 percent.

Maximum Instantaneous Rate of Turn. Data were available on only a handful of cases through unclassified sources, and the conditions under which they had been observed were infrequently cited. Given these tenuous circumstances, it was obvious that instantaneous rate of turn would have to be calculated independently not only to fill in the blanks but also to create a common plane of comparison. An aircraft's best instantaneous turn rate is calculated through the equation: $\omega = K\,(G_r/V_x)$, where:

ω = Instantaneous turn rate

K = A constant which converts radians per second to degrees per second and accounts for the value of gravity

G_r = Maximum radial G

V_x = Corner Velocity.

Two terms need further explanation. Radial G is the vector which defines the plane of a turn and is equal to the square root of cockpit G (G_c) minus one. Since the goal is to calculate the aircraft's best turning performance, G_c was set at the aircraft's combat G limit (placard limit) which represents the maximum gravitational force the aircraft's structure is built to withstand. Corner velocity (V_x) is the speed at which an aircraft can turn most efficiently, the velocity at which available G_r is exhausted. Available G_r increases as the square of velocity up to the structural G limit of the aircraft (G_c) Once that limit is reached, available G is constant, and increasing velocity results in a decreasing rate of turn. To grasp an aircraft's best turning performance, it is first necessary to determine its corner velocity.

The immediate problem was that data on V_x is rarely published. Consequently, the author had to rely on an expert-assisted estimative procedure. Two known variables, wing loading and thrust-to-weight ratio, were identified which generally correlated to the V_x values derived by decomposing published rate of turn data according to the above equation. An admittedly unscientific procedure was evolved which predicted to known values fairly accurately. This method was used to predict V_x values for all aircraft. These, in turn, were inserted into the rate of turn equation, and estimated instantaneous turn rates generated for all cases. While this technique was the best which could be improvised, the resulting estimates range to the high side. However, the bias appears consistent, so the results should not distort further applications unduly.

4.3.3 Target Acquisition Systems.

4.3.3.1 Sources

Data for this set was considerably less profuse than was available for airframes. In addition to the *All the World's Aircraft*, two other volumes from the Jane's series provided invaluable data: *Avionics* and *Weapons Systems*. Information was also gleaned from many of the periodicals cited above and from a few producers. Finally, The Analytic Sciences Corporation's excellent study, *The TASCFORM^{TM} Methodology: A Technique for Assessing Comparative Force Modernization* served as the template for assigning nominal values to those variables for which interval measures were not appropriate. Many of the values were subsequently altered to accommodate a different computational methodology, but the initial contribution was vital.

4.3.3.2 Comments

Several general notes concern the cases themselves. The aircrew has an inherent target acquisition capability irrespective of the systems installed. This was accounted for by creating a case called 'Visual', the values for which reflect an aircrew's unassisted ability to detect a target. Values on this case were developed through aircrew interviews and should be viewed as representative rather than absolute. Second, sufficient data were not available to differentiate among various laser ranging and target designation systems comfortably. Consequently, they were treated as generic cases, with values drawn from the limited data currently available. Third, authoritative data were not found on the radars installed on the latest Soviet fighters (Flanker, Fulcrum, Foxhound) or on the infrared search track systems on two Flogger variants. However, several articles speculate that their performance characteristics are essentially similar to those of some Western systems. The radars are identified in terms of the aircraft (e.g., 'FLANRAD'), with the performance data adapted from the putatively analogous Western system. The infrared search track systems are differentiated by the letter of the Flogger model in which they are installed (e.g., IRSTSB). Finally, in a few instances, the measurement variable is not entirely germane to a particular system (e.g., output power for visual acquisition or infrared systems). In these, a dummy value was derived from a regression equation which calculated the relationship between range and output power for the radar systems. These cautionary comments aside, the target acquisition system data base captures the bulk of the key attributes relevant to air combat.

Range-High Target and Range-Low Target. Data were collected which to the greatest extent possible reflected the system's capability to detect a fighter-sized target ($5m^2$) while in the search mode. Adjustments were made to the data when measurement under conditions other than these was indicated. The two measurements were included to account for superior target detection potential accruing to a system

which can distinguish a target while 'looking down' into ground clutter. Systems having this capability had data entered for both variables.[8] Air intercept radars capable only of acquiring targets at the same or higher altitudes were measured only on the 'High Target' variable, while air-to-ground radars had data entered solely on the 'Low Target' variable.

Data Points. The categories of significant data which the acquisition system could relate to the air-crew or weapons computer relative to the target were enumerated for each case. These include range, bearing, altitude, and airspeed. Data were entered as available from system description and imputed from other system characteristics when not.

ECCM Capability. The scoring scheme was adapted from the one developed by The Analytic Sciences Corporation. Values ranged from 0.7 for a system with a high susceptibility to electronic countermeasures to 1.1 for a system with very low susceptibility.

4.3.4 Air-to-Air Missiles.

4.3.4.1 Sources

Performance data on air-to-air missiles was drawn largely from Jane's *Weapons Systems* along with many of the aforementioned periodicals. Additionally, Gunston's *Modern Airborne Missiles* proved a most valuable source document. As was the case with target acquisition systems, The Analytic Sciences Corporation study provided a thoughtful matrix for extracting differentiating values for classes of nominally described variables.

4.3.4.2 Comments

Terminal Guidance Mode. Descriptive values (e.g., 'SARH' for semi-active radar homing) were entered in the data base. Associated values were assigned to a separate variable, guidance score. These values range from 0.7 for a command guided missile to 1.2 for one with active radar homing. They are further differentiated to reflect relative accuracy within class. For instance, an older infrared guided system is scored as a 0.9, while a more modern version is rated at 1.0.

Maximum Range-Head On and Maximum Range-Tail. Two maximum range values were entered to differentiate those missiles with all aspect capability from those which can only be launched from the rear hemisphere (primarily infrared guided systems). A missile with an all aspect capability is measured on both variables; one with a single aspect capability on only one.

Minimum Range-Head On and Minimum Range-Tail. This variable captures the distance required by the system to actuate its guidance system after separation from the launch platform. Criteria for entering values is as with the previously discussed variable pair.

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8 Radars possessing a 'depressed angle' rather than pure 'look-down' capability were treated as having a capability against lower altitude targets, but at attenuated ranges.

Effective Range-Head On and Effective Range-Tail. Adjusts the maximum range of the missile to account for the minimum range which must be covered before it is effective. It is computed with a formula borrowed from the TASC study: $R_e = R_{max} (1 - R_{max}/R_{min})$, where:

R_e = Effective range

R_{max} = Maximum range

R_{min} = Minimum Range.

ECM Susceptibility. Assignment of values for this variable adheres to the same concepts described above, but with the spectrum reversed. In this instance, a value of 0.7 reflects the system with the lowest susceptibility, while one of 1.1 marks a system which is highly susceptible to countermeasures such as flares, chaff, or electronic jamming.

Acquisition Mode. Two descriptive values are entered in the data base to indicate if a missile is capable of engaging targets at beyond visual range (BVR) or is limited to visual range engagements (VR). The descriptions are not associated with a numeric value, but are used to differentiate employment conditions under the scoring logic which modifies the guidance score according to its pertinence to a particular mission type.

4.3.5 Aerial Guns

Data for this category were extracted almost exclusively from Jane's *Weapons Systems*. Some additional data were also taken from brochures distributed by producers. A few externally mounted guns were included in this data set which is primarily concerned with internal weapons. Pod mounted guns were entered to permit their evaluation as a configuration option during weapon system score compilation if desired.

4.3.6 Relational Variables.

4.3.6.1 Aircraft Configuration Data.

The sources for the configuration data set were generally the same as cited above, with some notable additions. The International Institute for Strategic Studies' *The Military Balance* was used to identify the specific weapons available to a country for installation on its aircraft in a given year. Joshua Epstein's book *Measuring Military Power* was irreplaceable as a source of data on aircraft man maintenance hours per flying hour and, more importantly, as a guide on how to go about estimating values for systems on which data were not published. In the latter regard, operations analysts at Northrop Corporation's Aircraft Division provided insights into framing the estimation problem and practical documentation of estimation techniques.

For the most part, the entries in this data set are self-explanatory, indicating the presence or absence of a class of capability or the installation of a particular target acquisition system, air-to-air missile, or gun. Weapons system description documents such as *Modern Air Combat* catalogued possible or likely configurations. *The Military Balance* and various articles in periodicals and newspapers offered more definitive information on subsystems available to a given country. Finally, some subsystems were deleted from versions of an aircraft in deference to political considerations associated with its transfer. For instance, two versions of the Tigershark were configured, one with full up systems to included a radar missile and sophisticated ordnance release point computer capability (F-20A) and one without (F-20). The latter version is figured to be the one most likely to be approved for transfer to a Middle Eastern country like Jordan, owing to political sensitivities. A version of the F-16C (F-16CSC) was similarly configured for the same reasons.

The system configurations in this file represent a best estimate which is by no means definitive. The values of all of the variables in this file are changeable during the combat potential scoring process. This feature permits the user not only to correct entries that might be in error but also to switch subsystems and weapons to determine their impact on resultant combat potential.

Country of Production. In most cases, the entry on this variable reflects the original country of production. No attempt has been made to identify aircraft for which the recipient country might have some co-production responsibilities. Similarly, sources of secondary transfers are not singled out. There are a handful of exceptions, mostly pertaining to aircraft in the Israeli inventory. When an aircraft has been drastically modified by the recipient, the country of production annotation has been revised to reflect its largely indigenous nature.

Navigation Category. The descriptive values entered for this variable categorize the most sophisticated navigation system installed on the aircraft. They range from dead reckoning to a global positioning system. Not shown in this file are the differentiating values associated with these categories, which come into play in the combat potential scoring process. These values are scaled from 0.6 to 1.4 reflecting the navigation system's contribution to overall weapons system effectiveness.[9]

Man Maintenance Hours per Flying Hour (MMH/FH). Collecting sufficient data on this variable was an elusive task. While it suits the purposes of this study perfectly and is described by Epstein as 'the standard index of aircraft maintainability in peacetime,' little data is published on it. In fact, authoritative data could be obtained on only 21 aircraft, all but two of U.S. manufacture. The problem is compounded by the fact that the maintenance hours required vary from year to year, presenting a moving target. Because of these factors, it was necessary to adopt an estimative approach to fixing values for this vari-

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[9] The categories and associated values were primarily developed by Major William R. O'Brien, an F-111 Weapon Systems Operator with 15 years experience with aircraft navigation systems.

able. Epstein makes a solid case for taking this tack, noting that, while the estimated figure might not be entirely accurate, it is a viable delimiter of mission generation.[10]

The MMH/FH value associated with an aircraft is largely a product of two factors: the frequency with which maintenace is required and the difficultly of effecting the maintenance. These are most frequently measured as Mean Time Between Failure (MTBF) and Mean Time to Repair (MTTR) respectively. There are other intervening variables which some into play, such as organizational maintenance concepts, but these will be set aside here. An aircraft's MTBF is dictated in part by the number and reliability of its subsystems, while MTTR is a product of their number, complexity, and the maintenance procedure involved. Deficiencies in any of these areas can be offset by efficiencies in another. For instance, newer fighters like the F-20A and the F-16C have multiple subsystems, but the maintenance load is ameliorated through the reliability of advanced microelectronics and the pull-out, plug-in concept of primary maintenance associated with them. It stands to reason that if MTBF and MTTR were known for an aircraft, predicting to MMH/FH would be a fairly accurate process.

Unfortunately, those data are only marginally more available; so the estimation process has to fall back one level and focus on analogous reasoning at the subcomponent level. A 1980 article presented a body of data taken from Department of Defense reports which categorized 12 fighter aircraft according to their complexity and indicated their respective failure rates, associated workload, and man maintenance hours per sortie.[11] Various articles since then provided similar data on nine additional fighters. Using this data as a baseline, the configuration data base and aircraft descriptions were studied to identify those aircraft which were similarly appointed and were fitted with subsystems of the same vintage. Aircraft were subjectively grouped, and analogous MMH/FH values assigned to those aircraft for which the variable was undocumented. Multiple variants of a basic airframe were assigned the same value, unless their subsystems were substantially different. Some allowances were made for discrete reports concerning the reliability of individual systems. For instance, Jordan and Iraq are reportedly displeased with the maintainability and supportability of the Mirage F1, causing values for that aircraft to be elevated slightly.[12] The process worked satisfactorily for the majority of the aircraft in the file to generate data which portrayed at least some measure of the relative differentiation among the systems.

No doubt, the resulting values contain many inaccuracies, perhaps some serious. However, these need not be debilitating within the context and objectives of the study. The goal is to assess relative combat potential, and the values derived via this process do that adequately, albeit imperfectly. It can be

10 See Epstein, *Measuring Military Power*, pp. 153-165 for the estimative technique which he employed in his study and its justification.

11 See Benjamin Schemmer, 'Pentagon, White House, and Congress Concerned over Tactical Aircraft Complexity and Readiness'.

12 See Cordesman, *Jordanian Arms*, p.87

presumed at least that the errors will be no greater than those which might have resulted from picking 'authoritative' data from a single year.[13] The figures can be challenged individually, but as a whole they suit the purposes of this effort.

4.3.6.2 Relative Utilities

As noted in the previous chapter, a family of data had to be collected to glue weapon system attributes together at their joints. The data had to reflect the relative contributions of these attributes to definable mission outputs. The Analytic Sciences Corporation embodied this concept in its computational matrices. But the specific values (termed 'Weighting Factors') were not suitable for direct adaptation for three reasons. First, the TASC computational process differed from the one under consideration for this study in several important areas. Attempts to decompose or rearrange TASC's values to suit this study's scheme proved unfruitful. Second, the specific sources of the values and the considerations which went into them were opaque. Third, the values were predicated on a Central European operating environment. Since depicting the influence of the Middle Eastern operational environment on relative combat potential is a study goal, greater control over the factors considered in formulating the values for the relational variables is imperative.

Expert Survey Concept. The concept underlying the survey procedures employed by LeGrow and Jacoby in their explorations of Multi Attribute Utility Technique (MAUT) offered an attractive solution. The collective judgment of experts with first-hand knowledge of the phenomena being investigated is a valid measure of relative merit, subsuming the myriad of micro-considerations which defy individual quantification in an aggregated model. Despite the flaws in the previous applications of MAUT to military analysis outlined in Chapter 2, the survey technique on which it was predicated holds promise if questions are focused on a reduced basket of relationships with which the respondants are all intimately familiar and which could be considered at an intellectually more malleable level of abstraction.

Survey Formulation. Having been identified previously (Chapter 3), the junctures on which relative utility values were needed were organized into a tabular structure which graphically outlined the relationships to be evaluated. The basic questionnaire is included in Appendix C. A chart was prepared for each air weapons system component which arrayed the component's key attributes against the four combat missions being evaluated without reference to a particular system. The respondant was asked to make zero-sum determinations on the relative contribution of each attribute to combat success in each category of mission. The subcomponents having been scored, the respondant was asked in another chart to relate them under the same conditions. A final chart requested a similar rating of the air weapon system, oper-

13 Between the beginning of 1976 and the end of 1977, the mean time between failure rate for the F-15 increased from 0.76 to 1.30, bringing its MMH/FH value down to 41. Just two years later that value had dropped further to 33.6. The error resulting from taking a 'snap-shot' of the data could prove just as fallacious as employing the estimative technique described here.

ator proficiency, and command, control, communications and intelligence support (C^3I) contributions to success in each mission category. Finally, five questions were included to establish the respondant's system familiarity and fighter and combat experience. These data were used in discriminating among responses if substantial disagreement on individual values cropped up. An accompanying letter defined the Middle East the the employment region and gave a thumbnail description of a moderate intensity (compared to Central Europe) air operating environment.

Survey Administration. Experienced fighter pilots familiar with flying conditions and combat scenarios in the Middle East represented the best source of well informed survey judgments. Within the U.S Air Force at least, these are concentrated in Tactical Air Command's 9th Air Force, which serves as the air component of the United States Central Command (USCENTCOM). Weapons and tactics officers from the HQ 9th Air Force Directorate of Operations, whose primary job is developing combat plans and tactics for the Middle East/Southwest Asia contingency operations, were requested to participate in the survey, along with weapons and tactics officers from two fighter wings with USCENTCOM contingency commitments. Officers currently flying six different types of aircraft (A-7, A-10, F-4, F-15, F-16, and F-111) were included in the survey. Twenty-four are pilots, with one an F-111 weapons system operator. They reported an average of almost 2000 hours total fighter time (high:4600, low:325). Thirteen had accumulated an average of just over 500 combat hours, and eleven had some flying experience in the Middle East. All had flown in exercises which simulated a Southwest Asia combat environment. So that scenarios and objectives would be well understood, points of contact in each organization surveyed were briefed and asked to select those officers who would generate the most thoughtful responses.

Survey Results. Data entered into the questionnaire tables were reformatted into an automated file as values for the previously described relative utility variables. They were processed to determine the distribution of data for each variable and to extract relevant statistical information such as their mean, maximum, minimum, and median values and to establish a range of responses. Responses for 57 of 76 variables showed strong central tendencies, with median and mean values within 10 percent and with response ranges of 40 points or less. Responses for only 10 variables showed a deviation of more than 20 percent between the median and mean values. Of the 19 variables which displayed a range of values in excess of 40, the range for 15 could be reduced to 30 points by the removal of 3 or fewer of the extreme responses. The categories of variables which showed the most pronounced divergencies of opinion were those related to relative utility of radar guided air-to-air missiles, to that of precision guided air-to-ground munitions, and to that of target acquistion modes. Additionally, a lesser breadth of opinion was registered concerning the relative utilities of target acquisition systems and weapons payloads in the air defense and air superiority roles. While these divergencies tarnish the aura of the 'collective wisdom' imputed to the mean or

median values somewhat, they realistically mirror alternative positions often taken in arguments concerning weapon system development, employment, and outfitting priorities in the tactical community. These incidental disagreements aside, the survey results are sufficiently cohesive to produce relative utility values which might not hit the mark but which will be very close to it.

One of two values (mean or median) can be selected as a measure of central tendency to extract a typical score from data sets such as these. The mean is generally regarded as the best descriptor and is preferrable to the median if the data set is not highly skewed.[14] Only 19 of the 76 variables in this data set had skewness values of 0.5 or greater, and all of those were reduced to less than 0.5 through the removal of 4 or fewer outlying cases. This procedure was implemented. The resulting relative utility values are displayed in decimal form in the tables in Appendix C. While these values will be used for the remainder of this study, the scoring procedure is designed so that they can be easily altered by another user to reflect a different viewpoint or the different demands of another employment environment.

4.3.7 Air Inventories.

4.3.7.1 Sources

The combat aircraft inventories of the 22 nation study set were compiled from published air orders of battle (AOB's) for 1984 and 1985 and supplemented with annual projections through 1990. Primary source documents for the established inventories were the International Institute for Strategic Studies' *The Military Balance* , Interavia's *Air Forces of the World*, and the Jaffee Center for Strategic Studies' *The Middle East Military Balance.* Fragmentary data provided in these publications were also used in developing force projections through 1990. Several periodicals were essential in the latter effort. These included *Aviation Week and Space Technology*, *Jane's Aerospace Weekly*, and *The Air Force Times*. Additionally, projected acqusition information was extracted from two automated files, the *Arms Transfer Event Data Base* produced by Third Point Systems Corporation and the *Aerospace/Defense Markets and Technology* data base compiled by Predicasts Terminal Systems. Information on variables concerned with the quality of the maintenance forces was drawn from an automated version of the *World Military Expenditures and Arms Transfer Data Base* provided by the Arms Control and Disarmament Agency and from the World Bank's *World Development Report 1985*, the Central Intelligence Agency's *The World Factbook*, and JCSS's *The Middle East Military Balance.* Complete air order of battle (inventory) listings are included in Appendix D. All inventories reflect the end-of-year totals for the respective calendar year. Thus, the 1987 inventory figures represent estimates of the aircraft which would be possessed in December, 1987.

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14 See Blalock, *Social Statistics*, pp.69-70.

4.3.7.2 Comments

Data 'Smoothing'. Looking to future acquisitions, data were 'smoothed' to reflect logical entry into a country's inventory when no specific delivery schedule had been reported. The procedure broke blocks of ordered aircraft down into unit sized increments and spread these over the delivery period. Aircraft were treated as operational when sufficient numbers to constitute a unit were on hand.[15] To preclude the erroneous impression of ever-expanding inventories, aircraft which would be made obsolete by newer acquisitions were decremented as functional replacements became operational. This technique might provoke controversy, but it is logical in light of the limited absorptive and support capabilities of the nations in the set. Decrements were not enumerated on a strict one-for-one basis, but were forecast as functional conversions at the unit level.

Acquisition Estimates. Estimative techniques were also employed to project possible acquisitions for those countries on which scant planning data were available in open sources, particularly for those countries which are Soviet clients. Though virtually no information was available concerning their longer range air modernization plans, it is highly unlikely that some modernization will not occur, particularly in light of the recent introduction into Soviet forces of four new fighters. Here the procedure was to review a country's acquisition track-record, identify the relative spacing between new equipment acquisitions, and forecast the receipt of later model Soviet equipment. Without access to classified intelligence sources, the resultant inventories in the post-1986 period cannot be viewed as definitive, but they certainly represent one potential course of force evolution for countries like Syria, Libya, Iraq, and the PDRY.

Operationally Available Rate Estimates. Without classified data, it was impossible to determine precise operationally available rates (OAR) for countries and systems. Even at the force level, data had to be estimated based on an extrapolation from historical anecdotes.[16]. Historical data were evaluated in the context of a nation's military investments and assumed logistical capabilities to develop estimates of force level operational availability. The values ranged from 0.9 for Israel to a low of 0.3 for Libya.

Maintenance Personnel Estimates. No authoritative data were documented to establish the actual number of personnel available to perform primary maintenance on aircraft possessed by the nations under study. Since values for this variable are integral to the formulation of sortie generation boundaries, an estimative approach was dictated. Reviewing data on United States' and Soviet forces in Europe, Epstein calculated that approximately ten percent of total assigned air force strength accomplished the direct aircraft maintenance function.[17] This ratio might not be religiously applied in the Middle East, but it is

15 This treatment is optimistic, since the actual assimilation period would probably stretch over a year or more once the aircraft were in place. However, it is consistent with the concept of portraying an outside limit to combat potential.

16 Sources included Epstein, op.cit.; Cordesman, *Jordanian Arms, The Gulf and the Search for Strategic Stability*, and 'Lessons of the Iran-Iraq War'; and Staudenmaier, 'Iran-Iraq (1980 -) among others

likely that most of the nations in the region have borrowed similar personnel allocation concepts from their respective patrons.[18]

In lieu of more explicit data, the above mentioned source documents were reviewed to extract information on known national air force manning in the base years (1984 and 1985). Ten percent of total manning was assumed dedicated to direct maintenance. In the case of Israel, mobilized personnel augmented the active contingent. The number of estimated direct maintenance personnel was divided by the number of operational combat aircraft to identify the maintenance man to combat aircraft ratio which obtained in the base years. Iran presented a special problem because estimates on air force manpower and operational aircraft in the base year were admittedly speculative. Consequently, the maintenance man to combat aircraft ratio observed in 1979 was used, reflecting a more reasonable organizational allocation of manpower. Data on Lebanon were likewise tenuous, showing an exceptionally high ratio. Since the Lebanese Air Force is, for all intents and purposes, non-functional, this anomaly is not significant.

Future year projections were made by applying this ratio to forecast inventories. Ratios ranged from lows of below 1.5 (Libya, South Yemen) to highs in excess of 7 (Israel, Syria, Oman, Sudan, Iran). The Iranian ratio was atypically high (22) because of the minimal numbers of operational aircraft available. Since sortie generation calculations are also limited by the numbers of airframes available, this drastic deviation from the norm would have little actual impact on combat potential estimates.

Quality of the Maintenance Force. Data on the motivational variables identified in Chapter 3 were readily available. Rather than taking a 'snapshot' of a base year, data were assembled as a ten year average, predicated on the belief that motivational attributes and their impacts on personnel attitudes evolve over time. The technological adaptability variables were drawn from 1982 (percentage of age group in secondary school) and 1984 (literacy rate), indicating the relative literacy and educational background of personnel who would be available for military service in the subsequent study period. It must again be emphasized that these variables are 'soft' surrogates for the phenomena being studied and that this data set was compiled for illustrative purposes only. The force quality modifiers developed from it will be applied off-line to illustrate their potential impact and should in no way be regarded as definitive.

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17 For a review of his supporting data, see Epstein, op.cit., pp.203-207.

18 This assertion was validated in small part by a conversation with an aircraft maintenance officer from one Middle Eastern country who stated that personnel to aircraft ratio goals were derived from the U.S. model. He also noted that few of the countries with which he was familiar in the region had attained them.

4.4 Protest and Progress.

Those readers reviewing the data bases provided in Appendix B and Appendix C will undoubtedly identify variable values they believe fallacious. Just as surely, these occassional factual errors will provoke what Epstein terms the, 'storm of affronted protest,' which prevails when explicit judgments on numbers are made. But those judgments had to be made if the analytic process were to progress. The data are essential, and every care has been taken to ensure their accuracy. The exhaustive data lists are reproduced precisely so that technical experts can draw informed conclusions as to the relative reliability of the study's substantive findings. It is important to note that, while differing individual values might influence the outcome of specific combat potential computations, their impact will be discrete and predictably marginal and the methodology undergirding them unaffected.[19]

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19 Epstein cautions against analytical timidity when forced to employ data which might be open to question: 'Nor should anyone be cowed out of analysis by pseudoscientific demands that an inherently illusory certitude be demonstrated.' Epstein, op.cit., p.146.

Chapter 5
DATA REDUCTION

5.1 Criteria

Despite the economies applied in the variable selection and data collection processes, the sheer volume and differentiation of relevant data exceed manageable proportions. The derivation of aggregated values or scores which efficiently measure each of the critical attributes is pivotal in transitioning from raw data to a workable force level model. The data reduction process must adhere to many of the same considerations enumerated in the discussion of variable selection criteria in Chapter 3. While parsimony is a prime concern, it cannot be achieved at the expense of incomplete representation of the combat relevant facets. Conversely, no one facet should be asymetrically represented, either directly or indirectly. In addition, the creation of a relational scoring model presupposes a common mathmatical scale on which all variables are measured. Otherwise, the higher level computations are distorted by the varying native scales.[1] To complicate the problem further, the level at which the values are measured must be appropriate to their application. Composite or index variables identified in the data reduction process must, therefore, have ratio properties if they are to be subjected to subsequent multiplicative computations.[2] Consequently, a credible data reduction scheme must be judged against four criteria. Is it efficient? Is it comprehensive? Does it eliminate the distorting effects of disparate measurement scales? Can its products legitimately be entered into subsequent computations? The following sections will critically review alternative data reduction procedures, propose a procedure which capitalizes on their stong points, and describe its application to the data bases at hand.

5.2 Alternative Methods

Basically, the task is to create an indexed value for each relevant attribute which can be measured along a homogeneous ratio scale. Among the several methods available, three appear to have most currency in projects of this type, each with its drawbacks. These are discussed below, with an estimate of the degree to which they meet the above criteria.

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1 For example, if values for speed (1300kts), rate of turn (19.5 degrees/second), and combat range (390NM) are simply added, the value for speed accounts for over 75% of the resulting score.

2 See Blalock, *Social Statistics*, pp.15-22; LeGrow, *Measuring Aircraft Capability*, pp.10-20; and Rummel, *Applied Factor Analysis*, pp.222-223 for discussions of level of measurement concerns.

5.2.1 Single 'Marker' Variable

One approach is to select a single variable which the researcher believes captures the bulk of the significant variation in an attribute. In effect, this tack is an extension to the most basic level of the concept employed in identifying families of variables described in Chapter 3. As with any summarizing technique, the choice a single variable discards a measure of the information which describes the attribute. If the attribute is monolithic, the loss is negligible. With a multi-faceted attribute, it can be injurious. Single representative variables are identified in two manners. The researcher can simply assert that the variable captures the essential quality of the attribute. For instance, a previously discussed study stipulated specific excess power (P_S) as the sole indicator of combat aircraft maneuverability. While P_S plays a vital role in defining energy maneuverability, it fails to account for the equally important aspect of lateral maneuverability.

A second technique is to use statistical procedures to isolate a variable the values for which vary closely with others linked to the attribute under examination. For instance, the values for maximum speed at 36,000ft and at sea level in this data set are highly correlated ($r = 0.8278$). Similar relationships obtain for many variable pairs. Could one variable then be reliably selected to represent the attribute defined by both? From one perspective, the procedure has merit, as long as the functional relationship between the variables is valid and their correlation is not simply a statistical artifact. The process becomes more complicated, however, when more than two variables are associated with an attribute.

In a variation on the same theme which accommodates several variables, factor analysis can be used to define groupings of variables, with the variable having the highest loading selected as representing the attribute.[3] For example, Table 5.1 depicts the edited results of factor analysis of 18 of the variables in the airframe data set.

Since Factor 2 includes all of the maneuverability related variables, rate of turn (TURATE) could be selected to stand-in for the attribute in subsequent applications. While this technique is more powerful than the ones described previously, it still provides a less than comprehensive portrayal of an attribute's relative value.

Of course, selection of a single variable does not solve the measurement problem. The most direct solution is to index all observations of the marker variable to a baseline value. In the TASC study, all values were divided by the corresponding value for the F-4B, producing a homogeneously scaled data set with ratio properties.[4] Variables measured on differing scales could also be converted to standardized scores. This method provides an excellent mode for data comparison, but standardized values by defini-

3 Note that this application of factor analysis differs markedly from the efforts discussed in Chapter 2 in which all variables loading on a factor were incorporated in creating an attribute score.

4 One can safely assume ratio properties since all these variables are measured on interval scales with an implied although never observed natural zero point. See Bledock, op.cit., pp.18-19.

Table 5.1: Airframe Variables Factor Analysis

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
SURF	.84577			
CWGT	.83257			
SPAN	.77102			
TURATE		.84657		
TWPWR		.82407		
LIMG		.81333		
PSFL100		.80217		
CSPD		.50170		
STNS			.78263	
MAXORD			.76903	
GARAD			.68453	
FRANGE			.66447	
AIRAD			.59075	
SCEIL				.74275
LSPD				.65941
SPECENA				.60376
ASPD				.58949
SPECENS				.55247

tion have no natural zero point and, thus, lack the essential ratio property required for multiplicative manipulation.

To recapitulate, the isolation of a single or marker variable to represent an attribute is theoretically sound, particularly when solid statistical techniques leavened with expert judgment are employed in the selection. The technique engenders parsimony and negates redundancy. However, the marker's explanatory power varies in inverse proportion to the complexity of the attribute being represented. If complex attributes such as manueverability are on the table, a more inclusive technique is called for. The use of an indexing scheme to reduce disparate values to a common measurement scale has no major drawbacks, eliminating distorting effects and maintaining ratio properties.

5.2.2 Composite Indices

To overcome the loss of comprehensiveness inherent in the marker variable approach, some researchers 'build' composite variables which compress the multiple aspects of a complex attribute into a single value. Composites frequently convey meaningful performance related information unobtainable through any single component measure. Thrust-to-weight ratio, wing loading, and wing aspect ratio are all widely recognized as valid (although not sufficient) indicators of energy maneuverability, turning capability, and relative lift respectively. However, composites are legitimate only when their components have a functional

impact on the attribute being represented and their combinational mode reflects an engineering or operational reality. There is no inherent fallacy in composite variable construction but its application can be crippled through unrealistic variable combination. Rattinger proposed a multiplicative combination of speed, payload, and combat radius as a composite measure of aircraft performance. Sherwin and Laurance demonstrated the inadequacies of this procedure, noting the disproportionate impact of minor variations in variable values and its inability to deal with zero values.[5]

An operationally more legitimate composite variable, 'Payload Utility', was created in the TASC study multiplying target acquisition values by the weapons' values.[6] This procedure has considerable merit, since the two variables have a synergistic relationship. It is debatable, however, if the multiplicative process is a true representation of it. To borrow an anology from another section of the same report, it is questionable if a target acquisition system twice as capable as its predecessor were mated with a missile system twice as capable as its predecessor that the product would be four times as potent.

Nonetheless, this type of functionally defensible composite does meet the basic criteria and offers a data reduction option under rigorously controlled circumstances. The input variables must be critically scrutinzed to ascertain their adaptability to the process, and the computational scheme must reflect accepted operational relationships. The variables related to most of the attributes under evaluation here do not lend themselves to the composite approach.

5.2.3 Factor Analysis - A Reprise

At first blush, factor analysis possesses many of the qualities which satisfy the data reduction criteria outlined above. It is certainly comprehensive in that there are structural limits on the number of variables which can be analyzed. It is efficient, since groups of statistically related variables are arrayed into factors, each of which accounts for a specified proportion of the overall variance within the data set. This characteristic permits the researcher to peg the number of factors extracted for subsequent use to the number pertinent to the phenomenon under investigation. The factor scoring utility calculates relative scores for each case which add the absolute values for the variables in the data set in consonance with their loadings on the factor. A single value measured on a common scale is thus generated for each case on as many factors as are required to reach the desired level of explanation. Conceptually at least, the major drawback is that factor scores are interval level measures which are not natural candidates for subsequent computations involving multiplication or division. This failing is not insubstantial in a model which demands aggregation of the cumulative potential of a national inventory.

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5 See Sherwin and Laurance, 'Arms Transfers and Military Capability', pp.372-374. Other questionable composites include one commonly used in the military community which multiplies payload times radius to indicate relative ground attack lethality.

6 The procedure is actually more complex and is described in detail in Vogt, *The TASCFORM™ Methodology*, pp.2-9 to 2-14.

Chapter 2 sampled factor analysis based aircraft capabilities studies and highlighted the deficiencies encountered in using factor analysis to spring from raw variable values directly to an employment level combat potential assessment. In reviewing the factor analyses accomplished by Snider and LeGrow, it was observed that the attempts to relate a minimum number of factors to such overarching concepts as offensive and defensive capabilities or air-to-air and air-to-ground potential exceeded the reasonable bounds imposed by the nature of the technique itself and by the explanatory breadth of the variables considered. Exploring the more sophisticated application conducted by the Analytic Assessments Corporation, some additional deficiencies were highlighted. Implemented at the systems level, factor analysis defines variable groupings which are statistically valid but which often lack functional legitimacy. The calculation of scores for performance attributes includes values for variables which are operationally extraneous. Factor models incorporate no inherent logic for the aggregation of scores for multiple attributes (factors). These substantial defects in application aside, the factor analysis technique did demonstrate a facility for educing a common scale for the composite measurement of the contribution of multiple variables to the value of a specific attribute.

5.2.4 Summary

Each of the data reduction techniques investigated has significant assets and liabilities. The use of marker variables isolated by whatever technique is parsimonious but sacrifices too much explanatory power. The creation of composites is a valid but spotty solution of too limited applicability to satisfy the majority of analytical requirements in this investigation. Factor analysis offers the most comprehensive solution but is ineffective when applied exclusively at the weapon system level. Additionally, its output is not fully amenable to inclusion in subsequent computations.

5.3 A Minimalist Approach

A data reduction scheme which meets the stipulated criteria might seem unobtainable, but the kernel of a solution resides in a factor analysis process construed less ambitiously. The programmatic structure extruded in Chapter 3 provided a framework in which essential weapon system attributes and their functional relationships were qualitatively delineated. Therefore, there is no requirement for the simultaneous factorial analysis of all variables which pertain to an air weapon system. With attributes already defined and linked, data reduction need only be accomplished within the realm of each attribute itself. If all variables in the problem were functionally associated with the attribute being analyzed, the derived factor scores would be purged of the debilitating influence of irrelevant values. Setting aside the level of measurement problem for the moment, further elaboration of the minimalist factor analysis approach is warranted.

5.3.1 Variable Reduction

5.3.1.1 Analyze or Assign

The first task is to isolate and screen those variables contributing to the attributes identified in Chapter 3. To preclude the previously discussed distortions which arise when dichotomous variables are factor analyzed, they were excluded from this phase of the data reduction effort and relegated to insertion during the combat potential computation phase. The field thus narrowed, there are two alternatives for associating variables with attributes for factor analysis. Variables could simply be assigned to an attribute group based on their functional relationships, or they could be statistically grouped using factor analysis at the subcomponent (e.g., airframe, missile, etc.) level. The latter technique offers the advantage of previewing statistical anomalies and flagging possible redundancies. Reflecting on the observations made concerning earlier studies, reliance on factor analysis alone to accomplish this function could cause more problems than it solves. The happy medium is to begin with subcomponent level factor analysis and then modify its results judgmentally.

5.3.1.2 The Airframe Example

Principal components factor analysis was accomplished for all weapon systems subcomponents. Just the procedure to identify and allocate those variables associated with airframes will be described in detail, but the same procedure was applied to each subcomponent. Table 5.2 displays the results of the factor analysis of 26 variables, with values on 125 combat aircraft which are currently operated or might be acquired by Middle Eastern states.

Five factors were extracted, accounting for 85.9% of the overall variation in the data set. Variables loading on the first factor were primarily those associated with aircraft size and weight. The two exceptions were maximum thrust (MAXPWR) and specific energy at altitude (SPECENA). Speed and energy related variables loaded heavily on the second factor, along with the variable for wing loading (WLOAD). Fuel fraction (FUFRAC) loaded unexplainably on this factor, although weakly. Its expected association with range related variables (Factor 4) did not materialize. Those variables measuring energy and lateral maneuverability loaded distinctly on Factor 3, while Factor 4 encompassed range and air-to-ground ordnance related variables. Factor 5, which accounted for just 4.5% of the total variance was limited to wing aspect ratio (ARWNG) and wing span (SPAN). The association is unremarkable, since the square of wing span is the nominator in the wing aspect ratio calculation.

Vulnerability Attribute. The next step is to evaluate these statistical results within the context of previously identified airframe attributes and examine them for functional relevance and statistical redundancy. A key factor in an aircraft's susceptibility to engagement is its size. Bigger aircraft can be detected more

Table 5.2: Factor Analysis - 125 Combat Aircraft

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5
CWGT	.89504				
EWGT	.89093				
FWGT	.89053				
MAXPWR	.87697				
MWGT	.86434				
SURF	.85243				
SPAN	.68444				.60204
LSPD		.70448			
SCEIL		.67755			
ASPD		.65932			
SPECENS		.65390			
WLOAD		.65136			
SPECENA	.60071	.64482			
CSPD		.55114			
FUFRAC					
TWPWR			.85250		
PSFL100			.82569		
TURATE			.79935		
LIMG			.76382		
FRANGE				.73902	
GARAD				.69927	
MAXORD				.69763	
AIRAD				.67524	
STNS				.67392	
ARWNG					.93662

surely at greater range visually or with radar.[7] An aircraft's empty weight (EWGT) and fuel weight (FWGT) are subsumed in the calculation of its combat weight (CWGT), and it has already been stipulated that aircraft rarely operate in combat at their maximum weight (MWGT). Maximum power (MAXPWR) is irrelevant to the attribute and is assumed to load with these variables because larger aircraft require greater power. Therefore, EWGT, FWGT, and MAXPWR were eliminated from further processing, leaving the size attribute of the susceptibility to engagement calculation described by the variables combat weight (CWGT), wing span (SPAN), and wing surface area (SURF).

Airspeed/Energy Attribute. The variables which loaded on the second factor were for the most part measurements of various aspects of airspeed and energy. Wing loading (WLOAD) and fuel fraction (FUFRAC) are the major exceptions, and their inclusion in the factor is a statistical quirk rather than a meaningful functional association. Of the remaining six variables, two, specific energy at altitude (SPECENA) and specific energy at sea level (SPECENS) are products of calculations in which maximum

[7] Other attributes contributing to susceptibility to engagement are its speed and maneuverability, which contribute their own dynamics.

airspeed at altitude (ASPD), service ceiling (SCEIL), and maximum airspeed at sea level (LSPD) are elements. Since the specific energy variables constitute a more sophisticated measure of the speed/energy attribute, they were selected for insertion into the scoring process, along with rate of climb (CSPD). This screening eliminated the adverse influence of redundant measures of comparable phenomena and limited the remaining field to variables the values of which showed a more normal distribution than their antecedents.[8]

Maneuverability Attribute. Factor 3 variables are all statistically and functionally related to maneuverability (acceleration and turning). The design G value (LIMG) was subsumed in the calculation for maximum instantaneous turn rate (TURATE), and the thrust-to-weight ratio value (TWPWR) was used in estimating the denominator in the rate of turn equation and is closely correlated (0.98) to specific excess power (PSFL100). For the sake of efficiency, TWPWR and LIMG were eliminated from further processing.

Range/Endurance and Payload Attributes. The fourth factor encompasses variables associated with two airframe attributes: range or endurance capability and payload capacity. It is not illogical that these variable should load on the same factor statistically, since aircraft designed to carry large volumes of ordnance are also usually designed to carry it greater distances. More subtly, an aircraft with multiple external stations and and a heavier external load capacity can also carry more external fuel, thereby extending its range in certain configurations. However, the simultaneous consideration of payload and range related variables in the same same factor scoring module does not satisfy the goal of extracting separate values for the range and air- to-ground payload attributes. A composite score for a notional range/payload attribute would fail to capture the varying utility of these qualities in different mission roles.[9]

Consequently, this factor was split into two 'sub-factors' which correspond to the attributes for which measurements are desired: air-to-ground payload and range. A further subdivision of the range or endurance attribute was also required to accommodate processing considerations. Aircraft with singular mission roles (e.g.interceptors or ground attack fighters) had values entered only for the variable, area intercept radius (AIRAD) or ground attack radius (GARAD), which corresponded to their mission category. As a result, these two variables are replete with missing values, a fact which causes serious abnormalities in the factor analysis solution and permits factor scoring only if mean values are inserted in place of the missing data.[10] The solution was to process air-to-air and air-to-ground aircraft in separate runs.

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8 ASPD, LSPD, and SCEIL were skewed -0.256, -1.229, and -0.890 respectively. SPECENA has a skewness value of 0.069 and SPECENS one of .447.

9 Additionally, it should be remembered that the payload attribute for aircraft accomplishing air- to-air missions is already described in terms of specific missiles in the configuration file, making the gross measure of carrying capacity irrelevant.

10 An alternate was to create separate air to ground and air to air data bases with a variable akin to AAC's 'mission radius'. This solution was rejected as being unnecessarily duplicative.

Multi-role fighters were inserted in each. The final lineup was a factor group representing the air-to-ground payload attribute comprised of maximum ordance capability (MAXORD) and air-to-ground ordnance weapons stations (STNS); one focusing on the air-to-air endurance attribute, area intercept radius (AIRAD) and ferry range (FRANGE); and one capturing the air-to-ground endurance attribute made up of ground attack radius (GARAD) and ferry range.[11]

The Orphan Attribute. The fifth and final factor presents an interpretation dilemma. Wing aspect ratio is an indicator of relative lift, but it loaded on neither of the attributes which might have been anticipated, speed/energy or maneuverability. Since the explanatory power of this final factor was negligible and did not correspond to an essential airframe attribute, it was dropped.

5.3.1.3 Target Acquisition Systems, Missiles, and Guns.

An analogous process was accomplished for each of the other air weapon system subcomponents. To avoid repetition, just the high points and anomalies associated with them will be noted. As with airframes, variables described by nominal or dichotomous values were not entered into the factor problems. All of the variables in the target acquisition set loaded on a single factor. This was categorized as comprising the 'performance' attribute. The gun variable 'dispersion' is inversely related to accuracy. To channel the scoring thrust in a positive direction, this variable was transformed into a reciprocal. Two factors were extracted, with muzzle velocity and rate of fire loading heavily on one; and calibre, maximum effective range, and the reciprocal of dispersion loading on the other. The two factors were separated and scored as for airframes. In the air- to-air missile set, variables loaded on two factors. The first showed heavy loading for those variables related to a missile's performance or lethality (the six range related variables, speed, warhead weight), while the second was composed of those defining a missile's vulnerability to detection and target maneuvering (diameter, weight. and a negative loading for the maneuverability variable, G limit). Since the maximum and minimum range variables against high and low altitude targets had been the values in the maximum effective range computations, they were set aside. The G limit variable was transformed into a reciprocal, so that highly maneuverable missiles would score lowest on the vulnerability attribute. Two separate factor scoring problems were formulated to derive scores for each attribute.

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11 Although the fuel fraction variable did not load on this factor, it was tested along with the range variables in deriving factor scores. Its inclusion generated results which in some instances were at drastic variance with known relative endurance qualities. The probable reason is that the variable accounts only for relative fuel capacity and not fuel consumption efficiency. It is likely a valid relative indicator if a single class of similarly engined aircraft is under study. When applied across a sample as broad as this, its effects are counterproductive.

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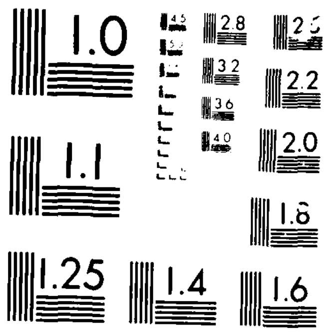
1.0
2.8
3.2
3.6
4.0
2.2
2.0
1.1
1.8
1.25
1.4
1.6

5.3.2 Attribute Indices Utilization

5.3.2.1 The Dilemma

As noted previously, the aggregation methodology contemplated for this study demands attribute values be measured on ratio scales. The influence exerted by negative factor score coefficients was preempted by the insertion into each attribute problem of only those variables which load heavily (statistically and functionally) on the factor and the conversion to reciprocal values of those variables which load negatively. Still, the fact that all raw data are transformed into standardized values prior to score calculation stands as a barrier. Several mathmatical solutions were attempted, all basically anchored by tried techniques for reversing the standardized scoring process.[12] In fact, an arbitrary system was employed in the analysis prototype. The data bases all contained systems the performance characteristics of which verged on the minimum essential to a weapon which would have even a negligible combat impact. A nominal zero surrogate factor score was created at a point one standard deviation below the lowest authentic factor score in each attribute set. Its inverse was then added to each score on the attribute. The solution is workable but unsatisfying, smacking of smoke and mirrors.

5.3.2.2 A Possible Resolution

The threads of a possible solution reside in the nature of the data processed in this particular string of analyses. Since nominal and dichotomous variables were excluded from factor scoring, values for all remaining variables could be assumed to have ratio properties, including a natural zero point.[13] It was observed that the few older aircraft which had no capacity to carry external ordnance (weapons stations and maximum ordnance = 0) still received a factor score value. Since the values for these cases constituted valid natural zero points when entered into the problem, would not the scores generated for them also constitute the zero point of the factor score scale?

To explore the potential, a 'control' case was created for each subsystem with a value of zero assigned to all its variables. Factor analysis was accomplished at the subcomponent level to determine if the insertion of the control case forced a redefinition of the factors (attributes). The basic groupings remained the same. The same procedure was employed for each attribute, this time with factor scores produced. The inverses of the values for the control cases were added to factor scores for the operative cases, creating sets of attribute values which intuitively had ratio properties. However, logical assertion does not legitimate the approach. A more substantial token of validity is required.

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12 The AAC study, for instance, speculated that a value five standard deviations from the mean might constitute a reasonable surrogate for zero.

13 As ludicrous as the example might seem, a notional aircraft with an absolute capability of zero would not fly. Thus, its airspeed, maneuverability, mission endurance, etc. would be zero. Despite the awkwardness of the conception, it is no more unrealistic to postulate than the notion of zero temperature or distance.

5.3.2.3 The Ratio Test

The key element in establishing credibility is to demonstrate that the adjusted scores possess the same ratio relationships as the input values. Reaching that goal with the study data files is patently infeasible. A notional three variable data set (VAR1, VAR2, VAR3) was created with values for ten cases. It is shown in Table 5.3. 'Case0' was assigned values of zero for each variable, and 'Case1' was assigned the value of a prime number. Subsequent cases were given a value which doubled that for the previous case. The data were subjected to principal components factor analysis. All showed a loading of one on a single factor, with factor score coefficients of 0.33333.

Table 5.3: An Observable Data Set

CASE	VAR1	VAR2	VAR3
Case0	0	0	0
Case1	1	3	5
Case2	2	6	10
Case3	4	12	20
Case4	8	24	40
Case5	16	48	80
Case6	32	96	160
Case7	64	192	320
Case8	128	384	640
Case9	256	768	1280

The scores are listed under the heading 'FACTOR SCORES (RAW)' in Table 5.4. The inverse of the raw factor score for 'Case0' (.61933) was added to the factor score for each case, and the results tabulated under the column annotated 'FACTOR SCORES (ADJUSTED)'. As can be readily seen, their values, with rounding, follow precisely the same progression as the input data.

Table 5.4: Adjusted Ratio Level Scores

CASE	FACTOR SCORE (RAW)	FACTOR SCORE (ADJUSTED)
Case0	-.61933	.00000
Case1	-.60721	.01212
Case2	-.59509	.02424
Case3	-.57085	.04848
Case4	-.52237	.09696
Case5	-.42541	.19392
Case6	-.23149	.38784
Case7	.15635	.77568
Case8	.93202	1.55135

5.3.2.4 The Distortion Test

No solution is without its price, and the application of the zero based scoring technique appears to exact two. The first is the most troublesome. The inclusion of a control case unarguably alters the spread of the study data sets.[14] As noted above, the factor patterns and score coefficients did not change, but a cursory review of scores for airframes with and without the control case showed the changes in the values of the derived factor scores for the active cases.

The magnitude and direction of the changes had to be determined along with their effect on relative rankings.[15] Factor scores were generated for five of the attribute groupings of the airframe data set under two conditions, one with the control case and one without. Ordinal rankings were determined for each attribute pair, and the results compared using a non-parametric correlation procedure. The results are depicted in Table 5.5. Clearly, the effects of the insertion of the control case on relative case rankings was negligible.[16]

Table 5.5: Impact of the Control Case on Rankings

ATTRIBUTE	SPEARMAN's RHO
Speed/Energy	0.9997
Maneuverability	0.9999
Air-to-Ground Range	0.9988
Air-to-Air Range	0.9906
External Ordnance	0.9991

To put the effects of the insertion of the control case in perspective, the same test was conducted, this time removing two active cases from the file (a fighter-interceptor and a ground attack fighter). The effect on the speed, maneuverability, and air-to-air range scores was comparable. However, the correlation of scores for the air-to-ground range and external ordnance attributes dropped to .9709 and .9566 respectively. Thus, it can be safely assumed that the insertion of the control case has at least no greater

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14 Ironically, the inclusion of zero values forced a more normal distribution for several variables which were skewed to the right.

15 All factor scores represent relative values within the confines of the factor space. Hence, the addition or deletion of any case, active or control, will change the relative scores and may change the relative rankings. These changes are a result of the standardization transformation which is applied to all absolute values prior to score generation.

16 Case by case results were also reviewed. The vast majority of rankings remained the same. Only a handful changed by more than two positions and just one by more than two positions (four). With the exception of the inexplicable four position change on one case, most of the changes could be traced to order reversals among variants of the same basic airframe (i.e., MiG-25R and MiG-25U, Mirage-F1A and Mirage-F1B). While the reason for this phenomena is unclear, its effect is inconsequential.

effect on relative case rankings than would the addition or deletion of active cases.[17]

Although the effect of the control case on the scores' rank orders was inconsequential, it is prudent to observe its impact on the score values themselves. The same paired lists of scores were compared through the Wicoxon Signed-Pairs Test to determine the direction and locus of differences. Output statistics reflect the same tendencies for each pair of lists. The means of the values falling in the first two quartiles were higher (less low) for the factor scores computed using the data sets including the control case. The reverse was true for values which fell above the median. The means, standard deviations, and and value ranges decreased slightly for the lists computed with the zero base. For each pair, the number of cases in which the zero based score increased was larger than the number in which the reverse was true. Within the more compact value ranges, scores toward the higher end of the scale increased slightly while those toward the bottom decreased, providing greater differentiation. Predictably, the two-tailed significance tests rejected the hypothesis that respective distributions were not similar (P = .0000). Coupled with the results of the rank order correlation test, these statistics suggest that the insertion of the control case does not adversely distort the sets of attribute factor scores. Conversely, an argument could be made that the zero values provided a more well-defined representation of the actual ratio differences among the active case input values, although this would be difficult to substantiate.

5.3.2.5 The Scale Test

The second price exacted by the adjusted scoring technique concerns the comparability of inter-attribute measurement scales. The raw scores for the zero point varied considerably among the attribute sets, ranging from a low of -1.90708 for the ordnance attribute to a high of -4.85510 for maneuverability. Thus, their inverses constitute an uneven threshold. The threshold values themselves would in effect determine a portion of the relative weight accorded each attribute during the additive phase of the scoring process, mirroring the problem caused by adding disparately scaled values discussed at the beginning of the chapter. After several false starts involving the computation of a grand mean across the attribute data sets, a variation on the indexing technique was adopted. The concept of indexing each attribute to the values for a given system satisfies the objective within the subsystem groupings, but fails to provide the desired common frame of reference across subsystems. A more viable alternative is to index each attribute score set to its own means. Considering the nature of the adjustment process, the mean of each score set is equal to the inverse of the raw factor score of the set's control case.[18] To cast the adjustment process

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[17] Changes in case composition are made regularly. The initial airframe file, for instance, grew from 86 to 125 cases over the course of the study. Since any list of cases represents a sample of a larger universe, the effect of the inclusion or exclusion of cases does not constitute a *invalidating* factor. It merely expands or contracts the space within which relative values are determined.

[18] Since the raw factor scores are standardized, their mean is 0. Adding the inverse of the raw factor score for absolute 0 to the mean case creates a mean equal to the value of the inverse.

in equation form, the adjusted factor score for Case1 would be calculated:

$f_{1a} = ((f_1 + (f_0 * -1))/(f_0 * -1)$, where:

f_{1a} = Adjusted Factor Score for Case1

f_1 = Raw Factor Score for Case1

f_0 = Raw Factor Score for Case0.

5.3.3 A Reduction Method

The path might have been tortuous and its end, like that of any data reduction scheme, a less accurate portrayal of reality than its contributing parts, but a modestly geared factor analysis technique has sufficient merit on balance to warrant its employment. Of the alternatives, it best satisfies the four criteria for effective data reduction postulated in the introduction. Applied at the subsystem level in conjunction with subjective appraisal, it defines the groupings of variables which most efficiently captured an attribute's value. At the attribute level, it generates raw factor scores which portray the relative value of each case on a given attribute. Finally, the ratio properties of case scores can be restored in relation to a control case, and the adjusted scores indexed to their means to create a common frame of reference across attributes and subsystems. The outputs from this chain of analyses form the inputs along with the values for the nominally scored variables and relational variables to formulae computing a weapon system's relative technical potential in combat roles. These, in turn, can be mated with with force propagation attributes to determine aggregate potential at the national level.

5.4 Data Reduction Results

The spadework done, it remains to generate adjusted factor scores for the various subsystem attributes and judge the results subjectively. This section will touch on the salient points associated with each data reduction iteration, capsulize results, and offer some subjective assessments of them. Complete listings of the adjusted factor scores for each subsystem are presented in Appendix E.

5.4.1 The Airframe Subsystem

Scores for the five attributes comprising the airframe subsystem were derived using the minimalist factor analysis technique described in the preceding section. The raw and adjusted factor scores for the top 15 scoring airframes are displayed in the tables for each attribute. Some cautionary notes are in order regarding interpretation of the data in the tables. Most importantly, the scores have been adjusted mathematically, but no modification has yet been made to account for the influence of nominally scored characteristics such as variable camber wings (maneuverability) or navigational capability (range). The perceptive reviewer will also note that, in some instances, airframes with slightly different raw factor scores

are shown as having the same adjusted factor score in the display tables. This anomaly is caused by the truncation for display purposes of the latter value to three decimal places. The automated files retain five decimal place values, which are used in aggregate score computations. The question may also arise as to why similar variants of an airframe have different scores on the same attribute, in particular maneuverability and detectability. It should be remembered that each variant is specifically configured, and its combat weight calculated on the basis of that configuration. Thus, the Tigershark variant whose radar has the continuous wave target illumination option installed (F-20A) is configured with AIM-7 and AIM-9 air-to-air missiles, while the other variant (F-20) carries only the lighter AIM-9's. Since combat weight or a composite variable of which it is a component is involved in the factor analysis of these two attributes, the scores can be dissimilar and legitimately so.[19]

5.4.1.1 Speed/Energy Attribute

The raw and adjusted factor scores for fifteen airframes which scored highest in the 125 airframe set are depicted in Table 5.6. The location of the Mirage-F1E at the top of the list might seem surprising. However, the most capable configuration of this aircraft has modifications to cockpit transparency and wing leading edges which give it a Mach 2.5 capability at altitude, while retaining a Mach 1.2 top speed at sea level. Like all of the later model Dassault fighters, it also has a high rate of climb. The placement of the MiG-25R, which set high altitude speed records, in sixth position might also take some reviewers aback. But the MiG-25's have a relatively poor speed capability at lower altitudes due to their airframe design and structural composition. In fact, the positioning of the MiG-25's is an endorsement of the principal that a single dimensioned 'marker' variable is insufficient to portray a meaningful picture of combat speed. Finally, it is instructive to note that 11 of the 15 aircraft which rank highest on the speed/energy attribute are not of U.S. or U.K. design. It has been observed that designers from these two countries have recognized the limited applicability of speeds in excess of Mach 1.8 in most combat scenarios and have subordinated technologically attainable maximum speeds to other considerations such as maneuverability.[20].

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19 Where multiple variants of a basic airframe have the same score on an attribute, the score is credited to a single designator describing all the variants to which the score applies (i.e., F15 A/B/C/D).

20 See Gunston, *Modern Air Combat* pp.14-17, and pp.186-193, for an informative discussion of the relative merits of various airframe attributes in combat.

Table 5.6: Airspeed/Energy Factor Scores

AIRFRAME	FACTOR SCORE (RAW)	FACTOR SCORE (ADJUSTED)
MIRF1E	1.71643	1.734
MIG29	1.36185	1.582
MIG31	1.32272	1.566
MIR2000C/T	1.31800	1.563
MIG25R	1.29513	1.081
MIG25/U	1.21650	1.520
MIR2000R	1.19940	1.513
F15A/B/C/D	1.18451	1.506
SU27	1.12331	1.480
MIG23G	1.09501	1.468
F15E	1.09396	1.468
MIR4000	1.09134	1.467
FA18L	1.08935	1.466
F16A/B/C/D	1.07952	1.462
MIG23B	1.07450	1.459

5.4.1.2 Maneuverability Attribute

The factor scores scaling relative maneuverability, Table 5.7, will perhaps provoke the most controversy, since the results seem to challenge the assumed ascendancy of the lightweight fighter in this attribute. However, it must be remembered that the attribute adresses maneuverability in two dimensions, energy maneuverability or acceleration and instantaneous turning performance. The former dimension contributes to the positioning of the F-15E and SU-27 at the top of the list. It also bears mentioning that the performance data on these fighters and on the MiG-29, Mirage-4000, and other new models are predicated on design goals or prototype test results and not on operational performance. It can be safely assumed that many of the values on yet-to-be-fielded systems will be altered when they reach operational status and track records are scrutinized. The high maneuverability rating of the planned export version of the Harrier (HARMK80) is consonant with its high thrust-to-weight ratio. In a continuation of a previous comment, note that 12 of the top 15 scores are awarded to fighters of American or British design. The maneuverability values shown will be further modified during the scoring procedure when the effect of devices which vary their wing camber is considered.

Table 5.7: Maneuverability Factor Scores

AIRFRAME	FACTOR SCORE (RAW)	FACTOR SCORE (ADJUSTED)
F15E	2.32053	1.468
SU27	1.87997	1.389
F16A	1.86495	1.386
F16B	1.85503	1.384
F15C	1.83723	1.380
F15D	1.78677	1.370
MIG29	1.74691	1.361
F20	1.72460	1.357
F20A	1.61733	1.335
MIR4000	1.61681	1.335
F16CSC	1.57651	1.326
F15CFP	1.55900	1.323
F16C	1.51086	1.313
HARMK80	1.50160	1.311
F16D	1.43996	1.298

5.4.1.3 Air-to-Air Range Attribute

The highest relative air-to-air range or endurance scores for interceptors and multi-role fighters are listed in Table 5.8. The F-15CFP is an F-15C configured with conformal fuel tanks (FAST packs), which increase its sub-sonic area intercept and ferry ranges considerably. While ferry range has no intrinsic combat quality, it suggests an airframe's endurance enhancement potential if external fuel tanks and fuel efficiencies are employed.[21] Only two of the newest Soviet fighters appear near the top of this group which is dominated by Western produced airframes.

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21 This association is arguable. But a high fuel, light weapons load option would be called for in some Mideastern combat scenarios where endurance is a primary concern. Iranian F-14s were reportedly employed in this configuration in the early stages of the war with Iraq. Thus, some measure of endurance expandibility potential was believed important enough to include. The same logic was used in deriving the air-to-ground factor scores.

Table 5.9: Air-to-Air Range Factor Scores

AIRFRAME	FACTOR SCORE (RAW)	FACTOR SCORE (ADJUSTED)
F15CFP	2.35225	1.717
F15E	1.78011	1.542
F14AC	1.84757	1.563
MIR4000	1.70393	1.519
F15C	1.52780	1.466
F15D	1.34757	1.411
TORADV	1.27140	1.387
MIR3NG	1.17925	1.359
F15A	1.17463	1.358
MIRF1E	1.03482	1.315
F15B	.99440	1.303
FA18L	.99292	1.303
SU27	.95923	1.292
MIRIIIE	.95836	1.292
MIG31	.86412	1.263

5.4.1.4 Air-to-Ground Range Attribute

The top two positions in the air-to-ground range attribute list, Table 5.10, went to the two Soviet built bombers deployed in Middle Eastern countries. The inclusion of the earlier model F-15 variants in this attribute group could be challenged. However, they do have a secondary attack capability if appropriately configured. In fact, some reports claimed Israeli Air Force F-15s participated in the bombing of the Osiraq nuclear reactor. The extraction of scores in a secondary role on this attribute acknowledges the potential while offering no suggestion of its attainment. The air-to-ground potential scoring logic will consider the mission of the unit of assignment and the configuration of the air weapon system before rendering a score at the force level.[22] The Tornado Interdiction Variant (TORIDS) recently ordered by Saudi Arabia scored well on this attribute, as did several of the older single purpose ground attack fighters (A-7E, A-7P, Mirage-5D2, and A-4H). The air-to-ground range scores will be given the added dimension of 'effective' range, when modified by navigation capability values in the scoring process.

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[22] Saudi Arabian F-15s are not equipped for air-to-ground missions, nor are their aircrews trained in them.

Table 5.11: Air-to-Ground Range Factor Scores

AIRFRAME	FACTOR SCORE (RAW)	FACTOR SCORE (ADJUSTED)
TU22BD	4.74706	2.924
TU16AG	4.29450	2.740
F15CFP	2.04871	1.830
F15E	1.49469	1.606
F15C	1.39035	1.563
TORIDS	1.36715	1.554
A7E/P	1.32630	1.537
MIR5D2	1.28591	1.521
F15D	1.25992	1.511
MIR3NG	1.19300	1.483
A4H	1.19024	1.482
IL28	1.10718	1.449
F15A	1.03215	1.418
FA18L	.93925	1.381
MIR4000	.62108	1.252

5.4.1.5 Air-to-Ground Ordnance Attribute

The air-to-ground ordnance attribute scoring problem considered two aspects: the maximum ordnance weight which could be carried and the number of positions on which it could be carried. The results for the top 15 scoring airframes are included in Table 5.12. The number of stations was included in the factor problem to capture the flexibility in ordnance mix engendered by multiple stations. The large number of weapons positions available propelled the A-10A over seven other systems which have a greater total carrying capacity. While this result might raise eyebrows, the facet of multiple weapons type capability which it portrays is important.[23] The F-4MOD in the third position is a 'paper airplane' at present, a design proposal developed by the Boeing Corporation and the Israeli Air Force to modify a portion of the IAF's F-4s drastically to increase range and carrying capacity. Note the presence of just two Soviet fighters in the top grouping, the SU-25 and SU-22 ground attack aircraft. Soviet fighters generally scored low on this attribute and on the air-to-surface range attribute, indicative of the relatively weak air-to-ground potential of aircraft supplied Middle Eastern clients by Moscow. During score computation, the adjusted scores will be further differentiated to account for the precision and non-precision ordance delivery capabilities of the host aircraft.

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23 An alternative scoring process was also tried for this attribute, simply indexing maximum external ordnance to the mean of the of the variable set. The results shifted some individual scores, but the rank order correlation remained relatively high (r_s = .7917). The indexed scores were retained for further sensitivity analysis in the combat potential computation phase.

AIRFRAME	FACTOR SCORE (RAW)	FACTOR SCORE (ADJUSTED)
TU22BD	2.96083	2.342
F15E	2.43530	2.095
F4MOD	2.39578	2.077
TORIDS	2.09097	1.935
MIR4000	1.88353	1.838
TU16AG	1.83921	1.814
A10A	1.82164	1.813
FA18L	1.57579	1.692
SU25	1.30224	1.571
F4EF	1.27546	1.546
F15CFP	1.23371	1.530
F16A/B/C/D	1.15844	1.495
LAVI	1.03694	1.448
MIR2000C/T	1.03520	1.437
SU22	1.01349	1.431

Table 5.12: Air-to-Ground Ordnance Factor Scores

5.4.1.6 Detectability Attribute

The final table, Table 5.13, lists the results of the vulnerability to detection segment of the factor scoring process. Unlike the preceding tables, Table 5.13 depicts the 15 airframes with the lowest scores, the ones least likely to be detected based on their size and combat configuration. The factor scores will be one of four elements of the vulnerability to engagement compuation. The others are speed, maneuverability, and electronic combat capability.

Table 5.13: Airframe Detectability Factor Scores

AIRFRAME	FACTOR SCORE (RAW)	FACTOR SCORE (ADJUSTED)
SF260TP	-1.00573	.499
SF260MW	-1.00279	.500
F5A	-.81966	.591
F5B	-.81507	.594
F5E	-.71492	.644
F5F	-.69438	.654
RF5E	-.69432	.654
F104GCF	-.67349	.664
F20	-.66937	.666
F20A	-.65667	.673
HARMK80	-.65291	.675
MIG21F	-.64302	.680
MIG21C	-.64136	.680
PRCF7	-.64136	.680
MIG21JKL	-.63966	.681

5.4.2 Target Acquisition Systems

As noted previously, all of the ratio level variables which described a target tacquisition system's detection potential loaded positively on the same factor. The results of the factor scoring process for the ten highest scoring systems, all multi-mode or air intercept radars, are depicted in Table 5.14. The large and powerful AN/AWG9, which is fitted to the F-14A/C topped the list, followed by the very capable Marconi/Ferranti FOXHUNTER air intercept radar carried by the Air Defense Variant of the Tornado. The AN/APG70 is a multi-mode system which will be installed in the F-15E, while the AN/APG63 and AN/APG64 are associated with operational variants of the F-15. The AN/APG67 is the multi-mode radar General Electrics produced for the F-20A, and the AN/APG68 is the up-graded system installed in the latest F-16's. The 'FLANRAD' and 'HOUNDRAD' are the radars installed in the two newest Soviet interceptors, the SU-27 Flanker and MiG-31 Foxhound respectively. Their performance characteristics have been estimated. The RDM is a multi-mode radar produced by Thompson-CSF for installation in export versions of the Mirage 2000 series. The detection values for the target acquisition effectiveness attribute will change somewhat when they are combined with nominally described characteristics (electronic counter-counter measures, track while scan, and doppler beam sharpening) in the combat potential computations.

Table 5.14: Target Acquisition System Factor Scores

SYSTEM	FACTOR SCORE (RAW)	FACTOR SCORE (ADJUSTED)
AWG9	2.24577	2.189
FOXHUNT	1.96710	2.042
APG70	1.96316	2.039
APG64	1.92754	2.021
FLANRAD	1.85371	1.982
HOUNDRAD	1.75172	1.928
APG63	1.66166	1.880
APG67	.90713	1.480
APG68	.84123	1.445
RDM	.71547	1.379

5.4.3 Air-to-Air Missile Subsystems

In no aircraft subsystem are the tradeoffs between performance and vulnerability to detection and defeat as evident as in the air-to-air missile category. The size required to house a more sophisticated radar based guidance system, a larger warhead, and sufficient propellant to generate longer ranges increases the potential that the missile will be detected and outmaneuvered.[24] Relative lethality scores are displayed in Table 5.15. All the missiles placing in the top ten depend on radar guidance. All but two, AIM-54 (PHOENIX) and AIM-120A (AAMRAM), have semi-active radar homing (SARH) terminal guidance systems, forcing the launching aircraft's radar to continue target illumination until impact. This factor, which increases the launch aircraft's own vulnerability, will be considered in the combat potential computation.

Several of the missiles which gained the highest lethality scores are also the ones most susceptible to detection and defeat, as demonstrated in Table 5.16. While the top of the list is occupied by an older missile not among the top performers, the Soviet AA-6 (ACRID), the remaining entries correspond to six of the missiles which ranked highest in performance.[25] The western edge in micro-electronics can be assumed to have contributed to absence of AAMRAM and the newest French radar guided missile (Super 530 D) from the top of the vulnerability list. The vulnerability scores will be further adjusted to account for the guidance system's resistance to electronic counter-measures and will denominate the overall combat potential score.

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24 Gunston points out, for instance, that a pilot who has detected a Mach 3 air-to-air missile with a 30G turning limit can outmaneuver it by making a 3G turn at 450 knots. See *Modern Air Combat*, p.15.

25 The 'B' model designator on Soviet missiles is assigned to those variants of the basic missile which have infra-red terminal guidance. The weights vary slightly between the guidance systems; thus, the differing vulnerability scores

Table 5.15: Air-to-Air Missile Performance Factor Scores

MISSILE	FACTOR SCORE (RAW)	FACTOR SCORE (ADJUSTED)
AIM54	3.88712	3.206
AIM7F/M	1.65487	1.939
SUP530D	1.26857	1.720
AA9A	1.20678	1.685
ASPIDE	.84823	1.483
AIM7E	.84823	1.362
SUP530F	.62061	1.352
AIM120A	.61216	1.347
AA7A	.58902	1.334
SKYFLASH	.52188	1.296

Table 5.16: Air-to-Air Missile Vulnerability Factor Scores

MISSILE	FACTOR SCORE (RAW)	FACTOR SCORE (ADJUSTED)
AA6A/B	2.80864	2.210
AIM54	1.75773	1.757
AA7A	1.13195	1.488
AA7B	1.08042	1.466
AA9A	1.06897	1.461
ASPIDE	.78797	1.340
SKYFLASH	.73226	1.316
AIM7D	.63438	1.273
AIM7C	.56567	1.244
SUP530F	.53167	1.210

5.4.4 Aerial Gun Subsystems

The assignment of meaningful descriptive titles to the two factors associated with aerial guns was not clearcut. Rate of fire and muzzle velocity loaded heavily on the first factor, while the other variables loaded moderately, with the exception of calibre, which loaded negatively. The second factor showed heavy loadings for calibre, maximum effective range, and accuracy. The identifications of the two groupings (rate of fire and effectiveness) are subjective approximations of the attributes they represent. The top ten scores for each attribute are listed in Table 5.17 and Table 5.18 respectively. The patterns depicted reflect reasonable relationships among the relative overall effectiveness of the weapons.

The two factor scores will be combined according to their relative contribution to overall performance variance in developing a single measure of gun effectiveness. When mated to an airframe, their effective-

Table 5.17: Aerial Gun Rate of Fire Factor Scores

GUN	FACTOR SCORE (RAW)	FACTOR SCORE (ADJUSTED)
GAU12U	1.58126	1.646
GAU8A	1.51434	1.619
MKIIMOD5	1.43403	1.586
M61A1	1.43403	1.586
NR30GAT	1.34511	1.556
XM27E1	1.00225	1.410
M39	.98490	1.403
GAU2BA	.90187	1.369
M28	.90187	1.369
GAU13A	.75365	1.308

ness will be further differentiated by the host's ordnance carrying capacity (rounds) in developing a net gun potential value. Several of the guns in the analysis are mounted in external pods. These are not mated to aircraft in the present configuration file, but scores were generated for them so that they could be considered as armament options in later analyses if desired.

Table 5.18: Aerial Gun Effectiveness Factor Scores

GUN	FACTOR SCORE (RAW)	FACTOR SCORE (ADJUSTED)
GAU13A	1.68924	1.573
GPU5A	1.44211	1.489
DEFA554	1.44211	1.489
MAU27	1.30054	1.441
KCA30	1.19218	1.405
XM8	1.10246	1.374
DEFA553	.97522	1.331
M621	.73419	1.249
M5	.63167	1.214
GAU8A	.63055	1.214

5.4.5 Maintenance Force Quality

As remarked earlier, the use of national scores to quantify relative measures of the quality of maintenance forces is an illustrative sidebar to this study. Nevertheless, the process through which the relative values were derived deserves brief mention. The four variables standing in for motivation (armed forces per thousand, military expenditures per capita, military expenditures as a percentage of GNP and as a per-

centage of central government expeditures) and the two suggesting technical capacity (literacy rate and percentage of eligibles in secondary school) were introduced into a factor problem. A notional country with zero values was added to the 22 active cases, and scores extracted. Although two factors emerged under rotation, all variables loaded significantly (at least 0.6) and positively on the first one. It was selected as being sufficiently representative. The raw and adjusted factor scores for all 22 countries are listed in Table 5.19. Adjustments to this data set were made in a slightly different fashion than for weapon systems. It was assumed that the the qualitatively most proficient maintenance personnel would generate one perfect maintenance manhour. Relying on historical observations, the quality of Israeli maintenance manpower was assigned a value of one, and all other observations were scaled to it in proportion to their raw factor scores.

Table 5.19: Maintenance Manpower Quality Factor Scores

COUNTRY	FACTOR SCORE (RAW)	FACTOR SCORE (ADJUSTED)
Israel	2.37109	1.000
Jordan	1.45151	.790
UAE	1.00045	.688
Iraq	.97870	.683
Oman	.75180	.631
Syria	.61468	.600
Qatar	.61238	.599
Libya	.46904	.567
Saudi Arabia	.44771	.562
Kuwait	.42115	.556
Egypt	.13173	.490
Lebanon	-.08363	.441
Iran	-.15596	.424
PDRY	-.24876	.403
Bahrain	-.34915	.380
Somalia	-.64010	.314
YAR	-.82650	.271
Tunisia	-.82826	.271
Algeria	-.83542	.269
Morocco	-.92810	.248
Ethiopia	-1.05612	.219
Sudan	-1.28085	.168

While these data are patently superficial, the relative associations among the countries are generally congruent with other studies and subjective appraisals. They should be approached gingerly, recognizing the fact that the input data captured only a fragment of the societal and organizational complex which determines force quality. The quality of maintenance force indices will be used to modify the man maintenance hours available data in the final step in the national air combat potential equations.

5.5 Summary

Data were reduced to a manageable matrix through a system which capitalizes on the most attractive aspects of several different data reduction techniques. The resultant body of data represents the relative quantities of each attribute which a subsystem possesses with the loss of significant information minimized to the extent permitted by any reduction scheme. Variables not lending themselves to higher orders of measurement were not forced into statistical problems ill-suited to their evaluation. Most importantly, the temptation to substitute neat statistical formulations for weighting relationships better determined by expert operational judgment has been eschewed. Within the context of the study framework, the bulk of the information required to calculate estimates of national air combat potential is now in place.

Chapter 6
AIR COMBAT POTENTIAL SCORE COMPUTATION

Having plowed through the variable selection, data collection, and data reduction processes, the final step, air combat potential score computation, is almost anti-climactic. The evolution of national force level scores follows the hierarchical path outlined in Chapter 3. Air weapons scores are first computed at the subsystem level. These scores are aggregated, in turn, at the air weapons system level in consonance with specified system configurations and relational utility values. The force propagation branch computations are less elaborate. Raw inventories must be transformed into operational mission specific force levels and potential sortie rates estimated. In the ultimate step, the two branches are joined to calculate the maximum relative combat potential a national force could expect to achieve under optimum circumstances on a given day. The nuts and bolts of the scoring sequence are outlined in the following sections, addressing the air weapon system process first.

6.1 Air Weapon Systems

6.1.1 Principles

Before dissecting the individual system scoring iterations, a few general comments are in order. The computational philosophy adopted in this phase is derived substantially from the TASCFORM™ methodology. While the following aggregation formulae and input variables deviate in some significant aspects, the path cut by TASC offered the most thoughtful and comprehensive approach encountered. Some relevant assumptions undergird the specific procedures.

First, air weapon subsystems and systems are treated as linear combinations of attributes and subsystems respectively. The single exceptions are measures of vulnerability, which are used to depreciate the potential of the system as a whole. While the assumption of linearity sacrifices the dynamic of synergy among system parts, the latter proved impossible to capture in a broadly based aggregated model.

Second, before subsystem scores are computed, the raw attribute values evolved in the data reduction phase are modified by nominal values for those characteristics which enhance or diminish their potential but which were not suitable candidates for factor scoring. Variables such as electronic combat suite and navigation capability are examples of modifying variables. Since all of the modifying variables were nominal, indicating the presence or absence of a combat related quality, the scoring strategy aimed at assigning

them values which reflected their functional impact on the attribute being modified. For the most part, analogous values were extracted from the TASC study, recast to accommodate procedural differences, and submitted to a panel of fighter experts for review. Values were adjusted in accordance with the panel's recommendations. As with any modifying factor or utility value in the computation process, their values can be adjusted by users to accommodate differing perceptions or priorities.

Finally, combat potential scores are computed as a function of the mission(s) in which the air weapon system might conceivably be employed. Four mission areas are addressed: air defense, fighter or air superiority, interdiction, and close air support. For the purposes of this investigation, the air defense mission includes point and barrier defensive counterair operations. The fighter mission represents over-the-battlefield air superiority and escort employments. Interdiction includes deep interdiction and offensive counterair operations, and the close air support mission area subsumes direct air support of ground forces, battlefield area interdiction, and counterinsurgency applications. Mission differentiation among the combat potential scores for a given system is a function of its configuration and the mission specific relative utilities extracted from the aircrew survey discussed in Chapter 4. As with the modifying variables, these utility values are user-adjustable during score computation.

6.1.2 Airframes

The relative potential of an airframe in a combat role (AF_r) is a product of the attribute values for airspeed/energy (NFSS), maneuverability (NFSM), and range/endurance ($NFSR_r$) and their respective relative utility values (e.g., US_r for the relative utility of the airspeed/energy attribute). The maneuverability attribute is modified by a factor (MA) which accounts for the influence of devices which vary wing camber, such as leading edge slats or maneuvering flaps, thus enhancing turning performance. The precise effect of such devices varies from airframe to airframe. In the absence of specific data, a general value of 1.2 was selected as representing the best estimate across the field. Specific values can be substituted when known. The range/endurance value is modified by two factors, one of which is linked to aerial refueling capability (RA) and the other to navigation capability (NA_r). Since aerial refueling is dependent on the availabilty of tankers, it will not be included in the baseline calculations. Its effects will be demonstrated in a country-specific example later. The navigation modifier aims to transform theoretical range into effective range by tapping the capability of an airframe to exploit its full range potential. An experienced navigator assigned relative values to navigation categories ranging from dead reackoning (.6) to global positioning system (1.4). These values were further differentiated according to the relative importance of navigation in each mission area. Scores for airframe potential are calculated:

$$AF_r = (NFSS*US_r) + (NFSM*MA*UM_r) + (NFSR_r*RA*NA_r*UR_r)$$

To demonstrate the implementation of this equation, the following example is the computation of the combat potential score for the F-16C in the fighter mission role. The F-16 has leading edge flaps and trailing edge flaperons for increased maneuverability and is equipped with an inertial navigation system.

$$AF_f = (.30*1.462) + (.43*(1.2*1.312)) + (.27*(1.2*1.113))$$

$$AF_f = 1.467$$

6.1.3 Target Acquisition Systems

The target acquisition computation assesses an aircraft's target acquisition systems' potential to detect, identify, and provide engagement related information concerning a target in various combat roles. Mission and aircraft non-specific scores (NFSTA) were derived for individual subsytems in the data reduction phase. The air weapon system configuration file mated subsystems to aircraft variants. As was the case with the airframe calculation, several of the initial subsystem attribute values are modified by nominally measured characteristics in the initial phase of the computation. Visual acquisition capability is enhanced by multiple aircrew members. Differing expert opinions were offered on the percentage improvement in visual acquisition afforded by a second set of eyes, noting that experience, workload, and personal qualities were key determinants. In the absence of a consensus, a factor (VA) of 1.3 was identified as an average position. Radar scores did not consider nominally described variables such as the presence of track while scan, doppler beam sharpening, and target illumination capabilities or address a system's relative resistance to electronic counter measures. Presence of a track while scan capability was estimated to enhance target acquisition by 30 percent in the air-to-air roles, and doppler beam sharpening by 20 percent in the air-to-ground roles. The target illumination modifying value was set at 1.2 for laser systems which provided a self-designating capability. These values were combined for each system into a modifying variable (TAA_r). Resistence to electonic countermeasures values (ECCM) ranged from 0.7 to 1.1. Values were awarded to systems based on descriptions of their frequency agility, side lobe suppression, and other features which diminish the effects of countermeasures. Utility values weight the subsystems' relative contributions to successful target acquisition in four combat roles. The target acquisition score (TA_r) calculation for an aircraft with visual (TAV), radar (TAR) and secondary subsystems (TAS) would take the following form:

$$TAV = (NFSTA_{vis}*VA*ECCM)$$

$$TAR = (NFSTA_{rad}*TAA*ECCM)$$

$$TAS = (NFSTA_{sec}*TAA*ECCM)$$

$$TA_r = (UTV_r*TAV) + (UTR_r*TAR) + (UTS_r*TAS)$$

Again, the F-16C in a fighter role is presented as an example. It is a single-seat fighter equipped in this configuration with an AN/APG68 multi-mode radar and a laser range finder. Since the laser range

finder has no application in a fighter role, the value for a secondary acquisition system is set to zero. The AN/APG68 has track-while-scan and doppler beam sharpening capabilities and has a relatively high degree of resistance to electronic countermeasures. Just the values in the final equation are depicted below.

$TA_f = (.32*.275) + (.51*2.290) + (.17*0)$

$TA_f = 1.256$

6.1.4 Weapons Payload

The calculation of weapons payload potential values (PL_r) involves a number of steps and, unlike those for the previous subsystems, is applied in two different forms depending on mission category. The expression for aerial guns will be presented first, followed by discussions of air-to-air missiles and air-to-ground ordnance.

6.1.4.1 Aerial Guns

Aerial guns were scored on two attributes, the rapidity and velocity with which they could deliver ordnance (NFSRAT) and its effectiveness (NFSEFF). A third factor associated with the host aircraft, the volume of ordnance available, must be entered into the equation. The total number of rounds carried by each aircraft was computed and indexed to the mean of the data set. The resulting variable (NRND) is used in the scoring process to modify the NFSRAT value. Since values for the relative utility of rate and volume of fire (URAT) and ordnance effectiveness (ULEF) had not been established via the aircrew survey, they were assigned subjectively. The equation for the mission non-specific combat potential score for an aerial gun (PLG) is:

PLG = (URAT*NFSRAT*NRND) + (ULEF*NFSEFF)

When applied to the M61A1 carried by the F-16C, the associated values are:

PLG = (.6*1.546*1.573) + (.4*1.073)

PLG = 1.889

6.1.4.2 Air-to-Air Missiles

The data reduction process scored air-to-air missiles on two attributes, performance (NFSPERF) and vulnerability to detection and defeat (NFSVUL). Two descriptive variables, guidance system type (GUIDTYP) and susceptibility to electronic countermeasures (ECS) modify the respective attribute scores. The values associated with guidance type ($GUDIDSC_r$) were assigned subjectively, considering such features as relative accuracy and the ability to track a target without continuing input from the launching aircraft. The values ranged from .7 for a command guided missile to 1.2 for one with its own active radar homing system. The modifying factors were further differentiated by their launch parameters

within or beyond visual range and the weight of that capability in air defense and fighter type engagements respectively. A weight of one was awarded an infra-red guided system in a fighter role at the low end of the spectrum, while a weight of 1.6 for an infra-red system with beyond visual range capability in the air defense role topped the list.[1] The susceptibility to electronic warfare modifier was also constructed subjectively, relying largely on descriptive information. Missiles least vulnerable to electronic warfare (to include chaff and flares) were assigned a value of .8. Those with high susceptibility were assigned a value of 1.1. Combat potential scores (PLM_r) were computed for missiles in each of the air-to-air roles according to the following equation:

$$PLM_r = (NFSPERF*GUIDSC_r)/(NFSVUL*ECS)$$

Note the use of the modified vulnerability value as a denominator. This combinational technique acknowledges that a system's vulnerability to defeat depreciates the value of its performance in full proportion. A sample computation is shown for the AIM-9L missile carried by many U.S and Western fighters and just recently exported to some Middle Eastern countries.

$$PLM_f = (.864*1)/(.643*.8)$$

$$PLM_f = 1.680$$

6.1.4.3 Air-to-Ground Ordnance

A single air-to-ground ordnance attribute score (NFSO) was extracted during data reduction, but greater differentiation is needed to account for precision guided munitions capability (PGMC) and avionics systems which enhance the accuracy of unguided ordnance delivery. Precision guided munitions are unarguably more accurate than their unguided cousins, producing more effective 'bang' for the same ordnance load 'buck'. However, the extent to which accuracy is enhanced over that provided by a combination of freefall ordnance, modern release point computers, and head-up displays is the subject of considerable debate. Individual comparisons of specific weapons, delivery parameters, and target arrays can be computed using weaponeering algorithms. However, these are not suited to application in a study such as this. Consequently, modifying values were assigned in accordance with the following assumptions. A stability augmented (SA) aircraft with a modern release point computer (CRP) and a head-up display (HUD) can deliver freefall munitions at accuracies approaching those of all but the most advanced precision guided systems. While precision guided munitions display greater accuracies, their effective employment can be degraded by dust, haze and darkness and by their somewhat rigid delivery parameters. While their theoretical accuracies might eclipse those of freefall ordnance by a factor of four or higher, their practical combat accuracies are more modest. The accuracy value of freefall ordnance delivered by a stabilized platform equipped with a release point computer and a HUD was assigned a baseline accuracy

1 No such system is currently operational, but the logic was included in the scoring sequence to permit expandability.

value of one. The generic precision guided munition (OAPG) was assumed to be 40 percent more effective on the average. A descending scale was used to score non-guided munitions delivery accuracy (OANG) ranging from 1 for a full suite of delivery assistance equiptment to 0.2 for an aircraft with just an iron sight. The two following equations apply:

$$PLO_{ng} = (NFSO*OANG)$$
$$PLO_{pg} = (NFSO*OAPG)$$

Substituting the values for the F-16C, which can deliver precision guided munitions and which is equipped with a CCIP/CCRP type weapons delivery computer and a HUD, the computations run:

$$PLO_{ng} = (1*1.495)$$
$$PLO_{ng} = 1.495$$

$$PLO_{pg} = (1.4*1.495)$$
$$PLO_{pg} = 2.093$$

6.1.4.4 Full Payload

Computing an aircraft's payload potential score (PL_r) is a matter of combining invidual weapons type scores in accordance with information specified in the configuration file and weighting them according to relative utility values by mission (UIM_r, URM_r, UGU_r). PL_r is computed separately for the air-to-air and air-to-ground missions. First in the air-to-air roles, the equation below applies:

$$PL_r = (UIM_r*(NAAMI/2)*PLM_r) + (URM_r*(NAAMR/2)*PLM_r) + (UGU_r*PLG)$$

The number of missiles carried (NAAMI or NAAMR, infra-red and radar guided respectively) is divided by two to establish an indexed basic load. Earlier tests showed that, without this convention, the cumulative weight of multiple missile scores dominated subsequent air weapon system calculations. The F-16C is again used to demonstrate the computation. The latest version of the F-16C equipped with the AN/APG68 radar is reportedly capable of carrying radar guided (SARH) missiles. The following calculation is based on a weapons suite of two AIM-7F's, two AIM-9L's, and an M61A1 aerial gun and addresses the fighter mission.

$$PL_f = (.39*(2/2)*1.680) + (.39*(2/2)*2.067) + (.22*1.889)$$
$$PL_f = 1.877$$

A similar set of equations determine payload potential scores in the air-to-ground missions. The relative utility weights for guided and unguided munitions are UPG_r and UNG_r respectively.

$$PL_r = (UPG_r*PLO_{pg}) + (UNG_r*PLO_{ng}) + (UGU_r*PLG)$$

Substituting values and relative weights for the F-16C in an interdiction role, the equation would read:

$$PL_i = (.48*2.093) + (.38*1.495) + (.14*1.889)$$

$PL_i = 1.837$

6.1.5 Vulnerability

As noted earlier, vulnerability to engagement has two contrary dimensions, detectability and the ability to avoid engagement once detected. The first dimension is captured by the size attribute scored in the data reduction process (NFSV). The second is a product of an aircraft's speed (NFSS), maneuverability (NFSM), and electronic warfare capability (EC_r). The first two avoidance attributes were determined previously. Electronic warfare capability is influenced by the ability to know that one has been detected (RWR) and to degrade the effectiveness of opposing target acquisition systems through passive (PECM) or active (AECM) means. These variables are nominally described, so the first task is to develop values which represent their influence in avoiding detection and engagement. The basic assumption governing the assignment of values was that possession of the full suite of electronic warfare capabilities applicable to a given mission would diminish an aircraft's vulnerability to the full value consistent with the relative utility of ECM in a combat role. Since the vulnerability equation is additive, an aircraft with a full complement of ECM assets would have an EC_r score of zero. Weights for the relative utility of each system in varying roles were determined subjectively after discussion with fighter experts. EC_r values were computed by the equation in which the presence of the characteristic is indicated by a 1:

$$EC_r = 1\text{-}((URWR_r{*}RWR) + (UPCM_r{*}PECM) + (UACM{*}AECM))$$

An aircraft with a full ECM suite would score 0; one with no ECM capability would score 1.

With the establishment of the EC_r values, all the information required to formulate the vulnerability equation was at hand. The offsetting nature of the two families of attributes posed a combinational challenge. Various strategies were tested before an approach which best portrayed the influence of the relevant attributes and was conducive to further applications was identified. Initial vulnerability to detection is largely a product of an aircraft's size. Speed, maneuverability, and electronic combat capability diminish that vulnerability somewhat, but their most significant contribution is in avoiding engagement once detected. The lower an aircraft's potential speed, maneuverability, or electronic combat capability, the higher the probability it will be engaged when detected. To preserve the additive combinational form, values for those attributes which diminish vulnerability first had to be transformed into reciprocals. The reciprocals were entered into the vulnerability equation in proportion to the relative utility values (UVS_r, UVM_r, UVE_r) established by the survey and added to the value for detectability multiplied by its utility factor (UVV_r) Thus, the vulnerability to engagement potential of a fast, maneuverable aircraft with a full electronic counter-measures suite would be largely limited to its detectability. In mathmatical form, potential for detection and engagement is calculated:

$$V_r = (UVV_r{*}NSFV) + (USV_r{*}(1/NFSS)) + (UMV_r{*}(1/NFSM)) + (UEV_r{*}EC_r)$$

Substituting values for the F-16C in the fighter role, the computation reads:

$V_f = (.22*.900) + (.28*(1/1.462) + (.32*(1/1.312) + (.18*0)$

$V_f = 0.633$

Applying formula across the spectrum of aircraft and missions produced reasonable differentiation. The least vulnerable aircraft in the air defense and fighter roles scored as being approximately half as likely to be engaged as the most vulnerable aircraft accomplishing those missions. The range of values for the interdiction and close air support missions was considerably greater due to the inclusion of bombers and low performance aircraft in those mission areas. The ratios between most and least vulnerable aircraft in the air-to-ground categories were 3.5 and 5.3 respectively, not unrealistic considering the the low survival expectancy of an aircraft like an SF-260 in a moderately dense defensive environment.

6.1.6 Combining Subsystems

The final step in solving the air weapon system combat potential puzzle is to assemble the pieces according to their relative utlities in individual combat roles. No modifying factors are involved, so the procedure is considerably cleaner than those discussed above. Airframe, target acquisition, and payload values are multiplied by their relative utility values (UAF_r, UTA_r, UPL_r) and added. The sum is depreciated by the value describing the aircraft's relative vulnerability to engagement. Mathmatically, the formula is:

$$ACP_r = ((UAF_r*AF_r) + (UTA_r*TA_r) + (UPL_r*PL_r))/V_r$$

Substituting the values for the previously described F-16C equipped with two AIM-7F and two AIM-9L air-to-air missiles, air combat potential in the fighter role would be calculated:

$$ACP_f = ((.33*1.476) + (.37*1.256) + (.30*1.877))/.633$$

$$ACP_f = 2.392$$

Alternatively in the interdiction role, the F-16C's combat potential would be computed:

$$ACP_i = ((.27*1.329) + (.37*1.023) + (.36*1.837))/.589$$

$$ACP_i = 2.374$$

Lacking a better term, the product of these equations will be referred to as 'Air Combat Potential Units' (ACPU's). It should be remembered that they represent the full theoretical combat potential of a specifically configured aircraft in a particular mission role *relative* to the potential of other aircraft in the data set in the same role. Thus, adding the ACPU's of a given aircraft does not produce a measure of total combat potential across a spectrum of missions. Altering aircraft configurations or changing the composition of the data set will yeild different ACPU values. The methodology was designed this way to permit evaluation of alternative configurations. Similarly, input relative utility values applicable to the entire mission set can be modified to accentuate a given attribute or subsystem corresponding to a specific employment environment or combat requirement. Again, the ACPU's generated will change. They are dynamic relative indicators not absolute measures of air weapon system worth.

6.1.7 Air Weapon System Results

Illustrations of the output from the air weapons system assessment process are displayed in the next four tables, one for each mission area. Each table lists the 15 aircraft which scored highest in the category, along with their Air Combat Potential Unit (ACPU) values and the values for their subcomponents. As previously, multiple similarly configured variants have been compressed into a single entry for editorial purposes, even through their exact scores differed slightly. Individual values for all aircraft arranged by mission area are included in Appendix F. All of the mission groups are dominated by newly operational or programmed aircraft, not suprisingly. As noted previously, the values on which their scores are predicated include measures of speculation and wishful thinking. Though their position atop the lists will no doubt be sustained, the margins of new and future systems' superiority can be expected to contract as operational observations become available.

6.1.7.1 Air Defense Mission

Table 6.1 contains the results from the air defense mission area computations. The margin by which the F-15E leads the pack is a product of the fact that it is configured with six AIM-120A (AAMRAM) air-to-air missiles. Neither they nor the F-15E are currently in service. Likewise, the ranking of the modified F-4 being considered by the Israeli Air Force is based on design information only, as is that of the Mirage-4000. Among the operational aircraft, current versions of the F-15 score well across the board, with particluarly high marks for payload potential. The F-15s carry six of the the newest models of the AIM-7/SPARROW. U.S. lightweight fighters (F-16, FA18L, F-20A) also fare well, their less formidable payload capability offset by lower vulnerability scores. The relatively low (within this group) position of the F-14AC despite its undisputed excellence in the interceptor role is a product of the fact that its configuration in this data set reflected the paucity of AIM-54/PHOENIX missiles available to its only operator in the area, Iran. Just two AIM-54's were loaded on the aircraft, and even that loading is overly generous. The three newest Soviet fighters (SU-27, MiG-29, MiG-31) place in the top grouping. The next highest scoring Soviet fighter (MiG-23G) is in thirty-second position, suggesting a wide generational gap. Final positions in the top grouping are occupied by the latest French and British entrants into the export market, the Mirage-2000 and the Tornado Air Defense Variant.

Table 6.1: Aircraft With Highest Air Defense Potential

AIRCRAFT	ACP_a	AF_a	TA_a	PL_a	V_a
F15E	5.242	1.582	2.042	7.762	.703
F15C/D	4.058	1.543	2.007	5.264	.711
F15CFP	3.985	1.510	2.007	5.953	.776
F15A/B	3.746	1.464	1.706	5.264	.732
SU27	3.148	1.474	1.796	3.692	.729
F20A	2.843	1.342	1.485	2.287	.596
F16C/D	2.715	1.458	1.452	2.213	.622
MIG29	2.554	1.416	.854	2.808	.633
FA18L	2.523	1.505	1.262	2.440	.672
MIR2000C/T	2.522	1.421	1.387	2.058	.636
F14AC	2.459	1.439	1.674	2.991	.820
MIG31	2.370	1.386	1.624	2.867	.820
TORADV	2.360	1.418	1.566	2.902	.822
F4MOD	2.187	1.358	1.279	2.535	.773
MIR4000	2.104	1.609	1.146	2.046	.739

6.1.7.2 Fighter Mission

Looking at Table 6.2, generally the same aircraft are represented. However, it is interesting to note the positional changes, with the smaller lightweight fighters creeping closer to the top of the list and the gaps between them and the F-15s shrinking. The MiG-31 and the Mirage-4000 drop out of the top group and are replaced by the F-16A and the austerely appointed version of the F-20. Neither the F-20 nor the F-16A carries radar guided air-to-air missiles. Despite the consequent lower payload scores, high maneuverability and low vulnerability qualify these lightweight fighters for inclusion in the top group. Comparing just these two tables demonstrates conclusively the benefit of employing mission sensitive relational values in a quantitative assessment of this type. Without them, operationally or environmentally pertinent considerations are overlooked to preserve statistical simplicity. The measuring instrument is leaner but incapable of detecting the legitimate and force posture relevant capabilities variations depicted in these two tables.

Table 6.2: Aircraft With Highest Fighter Potential

AIRCRAFT	ACP_f	AF_f	TA_f	PL_f	V_f
F15E	3.934	1.576	1.762	5.612	.726
F15C/D	3.065	1.520	1.720	3.754	.739
F15CFP	3.005	1.503	1.720	4.186	.795
F15A/B	2.800	1.423	1.469	3.754	.764
F20A	2.576	1.382	1.284	2.001	.594
F16C/D	2.392	1.476	1.256	1.877	.633
SU27	2.260	1.460	1.543	2.194	.757
FA18L	2.185	1.508	1.097	2.026	.692
F16A/B	2.158	1.513	.834	1.726	.614
TORADV	2.130	1.403	1.364	2.501	.806
MIR2000C/T	2.130	1.414	1.202	1.631	.657
F20	2.125	1.393	1.284	1.478	.649
MIG29	2.057	1.436	.756	1.968	.653
F14AC	2.045	1.427	1.454	2.426	.849
F4MOD	1.880	1.350	1.124	2.156	.802

6.1.7.3 Interdiction Mission

Moving to the first air-to-ground category, Table 6.3 lists the aircraft with the best potential in the interdiction role. Again, the programmed F-15E, the first of that series designed specifically as a true multi-role aircraft, is at the top. F-15 variants which have only a secondary air-to-ground role move toward the bottom of the group, their positions taken by multi-role fighters characterized by relatively small size, high performance qualities, and substantial although not superior ordnance carrying capacities. The exceptions are the modified F-4 and the Interdiction Variant of the Tornado. The former is planned to have significantly greater range and ordnance capabilities than existing F-4's, and the latter was designed specifically for the air-to-ground mission. Note the presence of only one Soviet fighter, the SU-27, in this group, suggesting an apparent lack of emphasis in Soviet design on those qualities most important in conducting interdiction operations.

Table 6.3: Aircraft With Highest Interdiction Potential

AIRCRAFT	ACP_i	AF_i	TA_i	PL_i	V_i
F15E	2.760	1.438	1.379	2.637	.669
F16C/D	2.374	1.329	1.023	1.837	.589
FA18L	2.272	1.374	.882	2.066	.634
F16A/B	2.261	1.352	.716	1.837	.571
MIR2000C/T	2.190	1.300	.981	1.660	.599
F4MOD	2.150	1.195	.941	2.498	.730
F20A	2.068	1.238	.928	1.327	.559
MIR4000	2.026	1.360	.842	2.069	.703
F15C/D	2.024	1.414	1.227	1.480	.676
F15CFP	1.951	1.388	1.227	1.694	.737
KFIRC7	1.898	1.262	.705	1.593	.619
TORIDS	1.897	1.291	.874	2.160	.764
F15A/B	1.848	1.331	1.055	1.480	.694
SU27	1.831	1.205	1.106	1.487	.693
F20	1.790	1.245	.928	1.327	.646

6.1.7.4 Close Air Support Mission

A review of the close air support mission group in Table 6.4 reveals some suprising results when viewed out of context. It is highly unlikely, for instance, that F-15's would be employed in a close air support role, although they possess attributes awarded high utility values by the aircrew survey. Their inclusion in the list does not imply employment in that role in force level aggreggations, it merely reflects theoretical potential. The absence of traditional CAS aircraft such as the A-7, A-10, and SU-25 is also noteworthy. Their positions below the top grouping are strictly a product of their higher vulnerability to detection and engagement. The A-10A, for example, was second only to the F-15E in total payload potential, but its vulnerability to enagement was almost twice as high due to its relatively lower speed and maneuverability. With the exception of these structural anomalies, the CAS listing again shows the high mission potential of small, lightweight fighters with good payload capacities, maneuverability, and speed.

Table 6.4: Aircraft With Highest CAS Potential

AIRCRAFT	ACP_c	AF_c	TA_c	PL_c	V_c
F15E	3.115	1.529	.749	2.764	.560
F16A/B	2.743	1.423	.482	1.842	.462
F16C/D	2.702	1.388	.596	1.842	.480
F20A	2.651	1.300	.462	1.691	.440
FA18L	2.593	1.445	.509	2.046	.525
F15C/D	2.410	1.482	.573	1.998	.570
F4MOD	2.401	1.235	.587	2.401	.612
F15CFP	2.362	1.518	.573	2.146	.610
F20	2.329	1.310	.462	1.691	.502
MIR2000C/T	2.251	1.316	.566	1.461	.497
F15A/B	2.247	1.367	.509	1.998	.588
F16CSC	2.103	1.414	.340	1.632	.539
MIR4000	2.068	1.430	.515	1.709	.594
KFIRC7	2.035	1.292	.379	1.432	.509
F4EF	1.944	1.120	.410	1.936	.616

6.2 Force Propagation

6.2.1 General Comments

The technical combat potential of air weapons systems is only realized in their employment. The force propagation side of the air combat potential equation addresses those factors which govern the quantity of available technical potential which a national air force might generate under optimum conditions in specific missions areas. As noted earlier, no attempt will be made to assess the relative operational, command and control, or support proficiency of individual nations in this study. Those factors constitute fertile ground for research, and values derived from such research could modify the suboptimal results produced here. In this effort, operational, command and control, and support capabilities will be assumed to be equal.

Accepting this assumption, four elements need to be considered in assessing an air force's propagation potential: the numbers of specific air weapon systems on hand, the fraction that will be available for employment, the role(s) in which they will likely be employed, and the number of times per day which they can be flown. The final product of these four elements describes the daily sortie potential (SP_r) for each system in its probable combat role(s). To keep the problem manageable, sortie potential will be calculated for a single day, representing the first day of combat. Surge operations are postulated over a 15 hour flying day, with no combat or maintenance losses considered and all non-essential maintenance deferred.[2] While these conditions are unrealistic, they serve the purpose of defining the outer boundary of

2 A detailed combat assessment model would have to include the effect of multi-day operations, losses, and maintenance deferrals. Operations analysts regularly employ methodologies which consider these and other variables in analyzing specific cases. However, the construction of a detailed combat model

a nation's force propagation potential.

6.2.2 Available Inventory in Role

The number and type of aircraft on hand were tabulated in the the air inventory file along with an indicator of the primary mission to which they are assigned. Also in the file was an operational availability rate estimated at the force level.[3] Determining the number of aircraft available for employment is simply a matter of multiplying the system inventory in a given year (INV_t) by the operational availability rate (OAR). For instance, of the 32 F-16C's Israel will possess in 1988, 29 would be available for combat at an operational availability rate of 0.9.

Allocation of aircraft to employment roles (AL_r) is a bit more cumbersome. Unit employment codes are geared to a generic mission category (e.g., fighter ground attack) which, for the most part, subsumes two mission areas (interdiction and close air support in the case of ground attack fighters). One unit type, multi-role fighter (FMR), encompasses all four. Without a specific combat scenario, aircraft are allocated equally across mission areas, with two notable exceptions. Bomber aircraft are cast only in an interdiction role, their effectiveness in close air support being suspect. Israeli F-15's assigned to multi-role units are assumed to perform primarily in the air-to-air roles for which they are best suited and not at all in the close air support role.[4] To acknowledge their deep interdiction potential, 20 percent of the available Israeli F-15's are allocated to that role. The remainder are equally distributed between the air defense and fighter missions. In equation form, operationally available inventory in role (OI_{rt}) is calculated,

$$OI_{rt} = INV_t * OAR * AL_r$$

The number of IAF F-15C's allocated to the fighter role on a combat day in 1988 would be computed,

$$OI_{f88} = (32 * .9 * .4)$$

$$OI_{f88} = 11.5.$$

6.2.3 Sortie Rates

The number of mission area sorties an aircraft can fly in a given day (SR_r) is determined by the length of the flying day (LOD), the duration of the mission (MD_r), the time the aircraft spends on the ground taxiing and arming (GT_r), and the time required to accomplish necessary maintenance (MT).[5] Other factors

is beyond the purview of this research project and would outstrip its resources.

3 In actuality, each system would have differing operational availibility rates. If credible operational availability data could be gathered across the spectrum of systems and countries being considered, they would provide a more refined product. In their absence, a gross force level estimate will have to suffice.

4 The F-15 is too expensive and uniquely capable an air-to-air system to be thrust into the heavy ground defense environment which confronts CAS missions.

5 Operations analysts at Northrop's Aircraft Division generously provided the outline of a simplified technique for estimating sortie rates. Their suggestions were essential in identifying the relevant factors and presenting a potential computation formula. Appendix B to Epstein *Measuring Military Power*

associated with availability of parts and supplies are also important, but will be assumed to be be equal across forces in this study. The length of the flying day has been stipulated to be 15 hours. Mission duration varies considerably as a function of environment and mission role. The environment was assumed to be equal for all forces and missions. Nominal mission durations were assigned subjectively by category. They ranged from a low of .75 hours for a close air support mission to a high of 2 hours for a deep interdiction mission. It is recognized that these values would be significantly different in a confrontation between Israel and Syria as opposed to one between Egypt and Libya, where greater distances would come into play. The mission durations used in these calculations represent regional averages and can be easily modified for country specific analyses. Ground time was estimated to be 45 minutes for air-to-air missions and 75 minutes for air-to-ground missions, which require more elaborate arming.

Three factors needed to be considered in estimating maintenance time for an aircraft flying a particular mission (MT_r): the hours flown on the mission (MD), the man-maintenance hours required to support one flying hour for the aircraft (MMHFH), and the maintenance personnel available for each aircraft (MXP). Since these had all been compiled previously, it was left to insert them in the equation,

$$MT_r = (MD_r * MMHFH)/MXP$$

To demonstrate its use, values for a MiG-21JKL operated in a fighter role by the Syrian Air Force are inserted in the equation.

$$MT_f = (1.5*18)/10.45$$

$$MT_f = 2.584$$

Thus, just over two and one half hours of maintenance time would be required between each mission.

If the effectiveness of maintenance personnel were to be considered, the MXP term would have to be modified by the support quality factor extracted earlier. This indexed value (Israel = 1) would be applied to the denominator in the formula. In the case of Syria, the support quality index value is .600. Consequently, the maintenance ground time for the same MiG-21JKL in a fighter role would increase to 4.306 hours if the force quality indicator were included. Unfortunately, the force quality values are low-confidence estimates and will be employed just to demonstrate their effect.

The determination of a potential sortie rate for an aircraft and mission combination in the context of a 15 hour flying day is a matter of inserting the above identified values in the equation.

$$SR_r = LOD\,(GT_r + MT_r + MD_r)$$

To again use the example of the Syrian MiG-21JKL in the fighter role,

$$SR_f = 15\,(.75 + 2.584 + 1.5)$$

$$SR_f = 3.103$$

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provided an an alternative methodology. The technique employed here borrows from both.

If the force quality modifier were considered, the potential sortie rate would decrease to to less than 2.5 per day.

6.2.4 Sortie Production

The number of sorties which an air force could potentially generate in each mission area on a given day can be determined by multiplying the number of aircraft available for a mission area by the system's sortie rate in that role. In mathmatic notation, the computation is,

$$SP_{rt} = OI_{rt} * SR_r$$

Substituting values for an Israeli F-15C in the fighter role in 1988,

$$SP_{f88} = (11.5*1.7)$$

$$SP_{f88} = 19.55$$

Again, the fractional values represent an average and could be truncated if desired.

Table 6.5 lists total one-day sortie production by mission for 21 Middle Eastern and North African countries in 1988.[6] The numbers in the far right column sum the total sorties across mission roles. The figures are uncontrolled for maintenance force quality, so some of the sortie production totals are considerably higher than would probably be the case in actual circumstances.

It could be observed that the overall Israeli sortie rate across missions (2.2) is lower than advertised performance in the Yom Kippur War. This possible anomaly can be explained by three factors. The average sortie durations used in the region wide computation are longer than were flown in 1973, and the flying day is shorter. Additionally, a substantial portion of the Israeli force is allocated to the more time consuming interdiction and close air support missions. While the Syrians could potentially (quality of manpower being equal) produce nearly as many total sorties, the mix is quite different. Israel could generate nearly twice as many air-to-ground sorties, with Syrian sortie production concentrated in the air-to-air missions. Iraq, Egypt, Saudi Arabia, Algeria, and Jordan, in descending order, are the only other countries in the region with a substantial sortie production capability. With the exception of Jordan, the estimates for the other countries in this group would be depreciated significantly if maintenance quality were included in the calculation. Table 6.5 also illustrates a point often made concerning the relatively low threat posed by Libya's disproportionately large and difficult to maintain inventory. With a low operational availability rate and a small native maintenance pool, Tripoli cannot propagate a credible number of sorties without enormous quantities of outside assistance. Several of the Gulf States also show discouragingly low sortie production, largely as a factor of small maintenance pools which have not kept pace with the influx of aircraft.

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6 Lebanon was omitted from this and other tables, since none of its aircraft are currently operational and there are no indications as to when that situation might change.

Table 6.5: Daily Sorties By Mission - 1988

COUNTRY	INVENTORY	ADX	FTR	INT	CAS	TOTAL
Algeria	266	79	55	31	106	271
Bahrain	12	2	2	1	3	8
Egypt	419	174	121	60	136	491
Ethiopia	150	0	0	22	52	74
Iran	47	13	9	32	60	114
Iraq	556	279	196	78	177	730
Israel	544	337	237	204	422	1200
Jordan	130	29	20	48	139	236
Kuwait	89	11	8	5	24	48
Libya	530	23	15	9	34	81
Morocco	93	0	0	30	136	166
Oman	50	6	4	9	50	69
Qatar	22	0	0	2	6	8
Saudi Arabia	214	60	41	65	144	310
Somalia	64	7	5	7	22	41
Sudan	49	10	7	11	38	66
Syria	528	445	317	114	241	1117
Tunisia	22	0	0	6	29	35
UAE	67	10	7	7	30	54
North Yemen	73	5	4	4	9	22
South Yemen	104	22	15	6	15	58

6.3 Combat Force Potential

The ultimate step in the assessment process is to meld the two branches into a value which which categorizes a nation's relative potential to conduct combat air operations under the employment considerations stipulated. This step transforms input data into a mission relevant potential combat output. Mathmetically, the process is straightforward.

$$CFP_{nrt} = ACP_r * SP_{nrt}$$

where,

CFP_{nrt} = Combat Force Potential for Country n in Role r in Year t

ACP_r = Air Combat Potential for an Aircraft in Role r

SP_{nrt} = Sortie Production for Country n in Role r in Year t.

Substituting the values for a Syrian Air Force MiG-29 employed in the fighter role in 1988,

$$CFP_{f88} = 2.057 * 21.58$$

$$CFP_{f88} = 44.39$$

Calculations are accomplished for each air weapon system in the inventory. The results can be evaluated individually or aggregated for the entire national force. Table 6.6 lists the 1988 combat force potential assessments for the Israeli and Syrian Air Forces in 1988. In this table, the quality of the respective maintentance forces is assumed equal. Force totals are summed at the bottom of each column.

Table 6.6: Comparative Force Potential - 1988

AIRCRAFT	INVEN -TORY	TYPE	ADX	FTR	INT	CAS
			ISRAEL			
A4H	18	FGA	0	0	8.33	25.71
A4N	50	FGA	0	0	26.26	77.19
F15A	18	FMR	51.72	26.72	6.49	0
F15B	2	OCU	5.72	2.96	.72	0
F15C	32	FMR	114.27	59.97	14.54	0
F16A	62	FMR	73.41	55.93	42.79	116.13
F16B	8	OCU	9.47	7.23	5.55	15.10
F16C	54	FMR	99.45	61.49	44.60	111.29
F16D	8	OCU	14.66	9.06	6.61	16.51
F4EF	100	FMR	80.12	49.90	39.71	115.53
KFIRC2	120	FMR	111.00	84.61	77.93	188.33
KFIRC7	72	FMR	98.19	70.22	58.41	132.12
TOTAL:	544		658.01	428.09	331.94	797.91
			SYRIA			
MIG17F	36	FGA	0	0	7.59	23.18
MIG21F	72	FIN	76.87	65.21	0	0
MIG21JKL	84	FIN	112.61	94.66	0	0
MIG21UM	20	OCA	22.49	19.03	0	0
MIG23B	24	FIN	25.80	17.23	0	0
MIG23E	48	FIN	43.13	33.24	0	0
MIG23F	70	FGA	0	0	19.09	53.95
MIG23G	36	FIN	44.13	29.24	0	0
MIG23UM	10	OCG	0	0	0	9.45
MIG25	38	FIN	36.44	23.20	0	0
MIG29	24	FIN	77.67	44.39	0	0
SU22	42	FGA	0	0	32.60	75.23
SU25	24	FGA	0	0	9.28	28.47
TOTAL:	528		439.14	326.20	68.56	190.28

Note: Undepreciated for Maintenance Quality

Reflecting back to Table 6.5 which showed the two countries with nearly equal undepreciated sortie production, the impact of air weapon system quality is vividly demonstrated. While Syria could potentially generate 30 percent more air defense sorties than Israel in a single day of surge flying, the quality of its aggregate output in that mission category is one-third less. Roughly 60 percent of Syria's air defense force is comprised of older MiG-21 aircraft, while the least capable Israeli aircraft flying the mission is the F-4EF, an aircraft which has significantly greater target acquisition and payload capabilities. Even the projected addition of two squadrons of MiG-29's to the Syrian inventory is not enough to offset the advantage accruing to Israel through superior air weapons system technology. Table 6.6 also illustrates Syria's relative impotence in providing air support to its ground forces. Even with the SU-25 added to its

inventory, Syrian capabilities in the interdiction and close air support roles are dwarfed by the Israeli potential. The Israeli MATMON B air development plan, drafted in the wake of the 1973 War, established creation of an air force capable of striking with overwhelming power anywhere in the region as a prime goal. This analysis reflects the attainment of that goal. As will later be seen, the IAF has built an air-to-ground capability unmatched by Syria or any other country in the region.

If the estimated quality of maintenance support is considered, the margin of Israeli superiority in all mission areas becomes even more pronounced. Table 6.7 depicts 1988 combat potential depreciated for maintenance quality.[7] The IAF would have almost a 2:1 superiority measured in Air Combat Potential Units in the combined air-to-air missions and nearly a 6:1 margin over Syria in the air-to-ground roles.

Looking to the region as a whole, Table 6.8 depicts the aggregated 1988 combat potential scores for 21 Middle Eastern/North African countries.[8] Any number of observations could be drawn from this chart. Overall, projected air combat potential development for all countries except Israel appears to have focused primarily on the creation of credible air defense and air superiority capabilities. Syria, Saudi Arabia, Iraq, and Egypt all will have amassed significant air-to-air combat potential by 1988 under projected acquisition plans. Development of commensurate air-to-ground capabilities has lagged. Two factors contribute. First, the aircraft, current and projected, acquired by Soviet clients in the region simply trail their western produced counterparts in air-to-ground potential. Second, the primary western supplier, the United States, has demonstrated a political reluctance to export significant quantities of capable air-to-ground aircraft to states which might pose a potential threat to Israel.

As a result, the combined air forces of Syria, Saudi Arabia, Jordan, and Iraq still fail to attain the levels of interdiction and close air support potential credited to Israel in 1988.[9] It should be noted that mission capabilities are not operationally matched in combat, with the possible exception of air superiority, and do not exist in a vacuum. Thus, the combined Arab lead in air defense potential should be operationally considered in the context of Israeli interdiction potential. Similarly, the preponderance of Israeli close air support capability is partially offset by the numerically superior ground forces Arab states could theoretically commit.

In the critical Persian Gulf, the Saudi acquisition of the Tornado package will boost its capabilities, in asscociation with other members of the Gulf Cooperation Council, to a position of parity with the other dominant air power in the region, Iraq, by 1988. In North Africa, Egyptian potential overwhelms

7 Since the measure of maintenance quality is indexed to the Israeli raw value, the Israeli figures are unchanged from the previous table.

8 A full listing of nationally aggregated combat potential scores differentiated by mission for the 1984 - 1990 time frame can be found in Appendix G.

9 This example does not imply that the combined combat potential of those Arab states could be cumulatively brought to bear against Israel. Although such an asssertion is occassionaly made in firing the political kettle, it consitutes a logistic, command and control, and intra-Arab political impossibility.

Table 6.7: Comparative Force Potential - 1988

AIRCRAFT	INVEN -TORY	TYPE	ADX	FTR	INT	CAS
			ISRAEL			
A4H	18	FGA	0	0	8.33	25.71
A4N	50	FGA	0	0	26.26	77.19
F15A	18	FMR	51.72	26.72	6.49	0
F15B	2	OCU	5.72	2.96	.72	0
F15C	32	FMR	114.27	59.97	14.54	0
F16A	62	FMR	73.41	55.93	42.79	116.13
F16B	8	OCU	9.47	7.23	5.55	15.10
F16C	54	FMR	99.45	61.49	44.60	111.29
F16D	8	OCU	14.66	9.06	6.61	16.51
F4EF	100	FMR	80.12	49.90	39.71	115.53
KFIRC2	120	FMR	111.00	84.61	77.93	188.33
KFIRC7	72	FMR	98.19	70.22	58.41	132.12
TOTAL:	544		658.01	428.09	331.94	797.91
			SYRIA			
MIG17F	36	FGA	0	0	5.69	18.50
MIG21F	72	FIN	57.76	48.07	0	0
MIG21JKL	84	FIN	84.61	69.77	0	0
MIG21UM	20	OCA	16.90	14.03	0	0
MIG23B	24	FIN	17.78	11.70	0	0
MIG23E	48	FIN	29.90	22.69	0	0
MIG23F	70	FGA	0	0	13.00	38.72
MIG23G	36	FIN	30.42	19.86	0	0
MIG23UM	10	OCG	0	0	0	6.87
MIG25	38	FIN	25.58	16.03	0	0
MIG29	24	FIN	56.07	31.48	0	0
SU22	42	FGA	0	0	23.22	56.90
SU25	24	FGA	0	0	6.91	22.56
TOTAL:	528		319.02	233.63	48.82	143.55

Note: Depreciated for Maintenance Quality

that which could be generated by Libya without tremendous assistance from the Soviet Bloc. To the south, Sudan's potential in all missions is modest and does not match the air-to-ground potential available to Ethiopia, while Somalia lacks a significant capability in all but the close air support roles. Across the Bab-el-Mandeb, North Yemen would clearly require assistance from Saudi Arabia to contest South Yemen's superiority in all mission areas. Finally, there is no doubt that Algeria will maintain a dominant air position in the Maghreb. The Tunisian and Moroccan air forces are simply too small and too underequipped to pose a credible match.

Table 6.8: Combat Mission Potential - 1988

COUNTRY	INVENTORY	ADX	FTR	INT	CAS
Algeria	266	69.17	50.88	15.85	59.68
Bahrain	12	1.93	1.53	1.16	3.72
Egypt	419	202.51	145.21	36.58	107.27
Ethiopia	150	0	0	12.59	38.62
Iran	47	25.55	15.63	25.80	66.35
Iraq	556	247.39	190.79	64.85	177.67
Israel	544	658.01	428.10	331.95	797.91
Jordan	130	46.34	32.53	43.73	152.29
Kuwait	89	16.37	11.55	2.98	17.76
Libya	530	25.86	17.22	8.99	30.49
Morocco	93	0	0	34.25	114.47
Oman	50	14.26	8.90	8.48	37.89
Qatar	22	0	0	1.99	6.14
Saudi Arabia	214	226.56	120.31	71.53	199.05
Somalia	64	3.45	2.79	2.20	8.35
Sudan	49	7.11	5.91	5.29	20.81
Syria	528	439.14	326.21	68.55	190.29
Tunisia	22	0	0	6.07	23.56
UAE	67	26.30	15.14	3.21	16.03
North Yemen	73	3.39	2.71	2.66	8.05
South Yemen	104	19.38	13.01	5.67	16.27

Note: Undepreciated for Maintenance Quality

6.4 Summary

These thumbnail analyses are representative only and by no means exhaust either the relevant questions pertaining to air development in the region or the analytical potential of the assessment methodology. Further examples will be offered in Chapter 7 which exercise these application attributes. What this chapter has demonstrated is that an analytical regimen which countenances the combined contributions of technical capability and force propagation to potential output in specified air combat roles is a viable assessment tool. The elimination of any one of these considerations (technical potential, mission relevance, propagation potential) leads to conclusions which lack military and, to some extent, political relevance. One may quarrel legitimately with individual input values in this data set and with the assumptions under which they were combined; but there can be no argument as to the essentiallity of their consideration in an analysis which attempts to measure the effect of weapons transfers on national air combat capabilities or regional balances.

Chapter 7
POLICY ASSISTANCE APPLICATIONS

The goal of this research was to develop a military analysis tool which could assist policy makers in developing, evaluating, and supporting security assistance packages. The mechanism has been described and implemented and some individual results highlighted, but its efficacy in producing decision relevant data still needs to be established. The model as it stands produces results dictated by the input data and underlying assumptions. As such, its output is static and conceivably unresponsive to the problems, priorities, and perceptions of a user evaluating a specific security assistance question. In Chapter 1, it was noted that a model which could not be molded to meet user defined criteria would inevitably fail to generate policy relevant results. To avoid this pitfall, features have been included in this methodology which permit user directed modifications of assumptions and, in many instances, of input data. This chapter will demonstrate the sensitivity of these features in evaluating a security assistance question and suggest some additional categories of questions to which it could be directed.

7.1 Criteria

E. S. Quade, in his discussion of the role of analysis in supporting policy decisions, posits a cycle which an analytical regimen must transit. He describes a ten step process which begins with the determination of analytical objectives and criteria, flows through data collection and model design, applies the model to assessing alternatives for evaluation and interpretation, and ends with the reassessment of assumptions and alternatives for reintroduction into a subsequent analytical phase. Without delving into the paradigm's elements too deeply, two key concepts bear mention in the context of this effort. Most significantly, the analytical process is iterative. It must accommodate the introduction of evolving alternatives and changing assumptions if it is to present the decision maker with options pertinent to his problem. The model which it employs must, therefor, be adjustable at each phase of its operation. The interpretation of analytical output demands decision maker participation, the effectiveness of which is largely a product of his appreciation of the methodology's assumptions, input data, and combinational scheme. To question and change any of these essential elements, the decision maker must have access to them and be able to make alterations to suit his requirements.[1] The methodology proposed for assessing the impact of air weapon systems' transfers on recipient force structure and regional military balances possesses those attributes

[1] See Quade, *Analysis for Public Decisions*, pp. 50-66 for a thorough discussion of the steps in policy analysis and their interrelationships.

which permit the decision maker not only to test alternatives but also to alter the conditions under which they are tested.

The analytical example offerred in the next section is geared to illustrate the methodology's flexibility in responding to hypothetical decision maker directed changes at various junctures in the analytical process. In particular, the capability to modify input data and underlying assumptions is emphasized, along with the potential to derive new alternatives and evaluate their effectiveness. Methodological results will be interpreted strictly on their own merits, recognizing full well that the actual interpretation process would by necessity involve a host of considerations exogenous to the model.

7.2 Enhancing Jordanian Air Combat Potential

Rather than trekking through a series of discrete problems, this example will consider a single security assistance question and its permutations. The security assistance dilemma presented by Jordan's requirement for an advanced air defense fighter embodies many of the elements which confound arms transfer policy makers. Jordan is a long- time American arms client whose strength and stability are critical to regional security. It is threatened sporadically by a much more powerful neighbor, Syria, whose Soviet patronage and radical tendencies are antithetical to Washington's regional objectives. Jordan is also putatively threatened by Israel, whose policy of aggressive deterrence includes regular overflights of Jordanian territory. Conversely, Jordan itself is viewed as a threat by Israel, America's closest ally in the region. Consequently, any security assistance to Jordan must be evaluated not only in the context of its own defense but also in terms of the potential threat it poses to Israeli security.[2]

From a military perspective, Jordan is highly vulnerable to incapacitating air attacks from either of its more powerful neighbors. Much of its industry is concentrated in along the Dead Sea; 60 percent of its agriculture is confined to the eastern Jordan Valley; and its economy is highly dependent on free access to the port of Aqaba. Its power and water supplies are likewise inviting air targets. Both the Syrian and Israeli air forces currently have the capability to overwhelm Jordan's air defense system, and those capabilities will increase over the next five years as new systems are introduced. The air component of Jordan's air defense system is currently limited to 38 Mirage F-1 B C E's, with which Amman is not entirely satisfied.

Against this admittedly sketchy backdrop, the elements of a question to which the air capabilities methodology could be applied can be drawn. In 1985, Amman requested United States assistance in enhancing its air defense capabilities to counter the projected threat into the 1990's. One component of

[2] See Cordesman, *Jordanian Arms and the Middle East Balance*, pp.39-42, for a discussion of threats to Jordan and incidents of Israeli overflights. This example will not treat the political dynamics of the problem or become embroiled in the debate of who threatens whom. The intent of this section is to demonstrate methodological flexibility, not to evaluate Middle Eastern political questions. The influence of political perceptions and objectives would be applied outside of the methodology.

the package was a request for 40 air defense fighters.[3] The American response is currently adrift in a political maelstrom, and it is not the intent of this illustration to reenergize it or advocate particular alternatives. Nonetheless, the Jordanian air defense enhancement request provides a demanding vehicle with which to flex the proposed analytical methodology. What pertinent questions are tractable to quantitative military analysis? First, it can evaluate the relative combat potential of alternative air weapon systems in the projected employment environment. Second, it can test the impact each alternative makes on national air capabilities. Third, it can assess the effect of the proposed arms transfer on the regional military balance under varying scenarios. In the Jordanian case, the first problem is to identify and evaluate the aircraft and configurations feasible for transfer under the constrictions imposed by the terms of the request and American transfer policy.

7.2.1 Aircraft Alternatives

Two aircraft are likely candidates to meet Jordanian requirements: the F-16C and the F-20A. In deference to probable political restrictions, it is hypothesized that the aircraft would have to be configured in such a way as to preclude their effective employment in an air-to-ground role. Further, the transfer of a capability to launch radar guided air-to-air missiles is stipulated as being destabilizing vis-a-vis Israel.[4] It might be remembered from a previous chapter that modified versions of the F-16C and the F-20A have already been configured in the study data set, identified as the F-16CSC and F-20 respectively. The F-16CSC is equipped with the AN/APG66 radar which does not have the capability to illuminate targets for radar air-to-air missile guidance. Additionally, the CCRP/CCIP feature of the fire control system has been omitted to complicate effective air-to-ground ordnance delivery. The AN/APG67 radar associated with the F-20 has been similarly limited, with options to support BVR radar guided missiles and enhance ground tracking capabilities eliminated. Both systems will be configured for the air-to-air role with four of the latest export version of the Sidewinder (AIM-9P), which lacks a foreward hemisphere engagement capability. To extend the frame of reference, a French aircraft, the Mirage-2000C, is also evaluated on the surmise that it might be an alternative from the Jordanian perspective if Washington denied Amman's request. Of course, the French alternative would not be subject to U.S. imposed constraints; so its configuration was not altered from that already exported to other Middle Eastern states. Air-to-air combat potential scores were computed for each aircraft using the techniques, assumptions, and data discussed in earlier chapters. The results of the initial inquiry are displayed in Table 7.1.

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3 See Gordon, 'Administration Urges Congress to Accept Arms Sale to Jordan', for a description of the requested arms package and its supporting rationale.

4 It needs to be clearly understood that these particular assumptions and other like them cited in this example are included for the purposes of illustration only and do not correspond to U.S. government policies, perceptions, or practices.

Table 7.1: Combat Potential in Air-to-Air Roles

AIRCRAFT	AIR DEFENSE POTENTIAL	FIGHTER POTENTIAL
F-16CSC	1.541	1.734
F-20	1.933	2.125
Mirage-2000C	2.522	2.130

Note: Scores computed with system defaults

As a reminder, the numbers shown represent units of air combat potential (ACPU's) credited to the air weapon system alone. ACPU's are relative measurements within the confines of the study data set. They do not connote absolute values of independent merit. The higher scores awarded the F-20 in relation to the F-16CSC are primarily the products of a more effective radar and a lower vulnerability to engagement. The fact that the F-20 has a greater gun ordnance capacity also plays a marginal role in producing higher ACPU ratings. These factors offset the relative superiority of the F-16CSC airframe in both roles. The Mirage-2000C garnered the highest ratings largely because of its equippage with radar guided air-to-air missiles, which are afforded a high relative utility in the air defense mission. In reviewing the initial findings, note that the assumptions under which the default relative utility values had been established were predicated on a nominal regional employment environment which did not correspond entirely to the situation facing Jordan. Given the compact defensive environment, it is probable that the range attribute is overemphasized, as is the relative utility of radar guided air-to-air missiles. To correct this deficiency, utility values were adjusted to lessen the impact of range and radar missile capabilities on the overall computation. The results of the second iteration are displayed in Table 7.2.

Table 7.2: Combat Potential in Air-to-Air Roles - Revised

AIRCRAFT	AIR DEFENSE POTENTIAL	FIGHTER POTENTIAL
F-16CSC	1.703	1.737
F-20	2.133	2.134
Mirage-2000C	2.432	2.147

Note: Scores computed with revised utility values

While the Mirage-2000C still receives superior scores due to its multiple missile type carriage, its margin of superiority lessens as a function of the lower relative utility awarded the radar guided missiles.

The impact of the changed utility values on the comparison between the F-16CSC and F-20 is negligible, although both score higher as a result of the modifications. If the inquiry were terminated here, it would appear that the F-20 represents a more favorable American alternative when only air-to-air applications are considered. It is also evident that either American alternative is inferior to the Mirage-2000C when combat potential is considered under asymetrical political constraints in an employment vacuum. Of course, only the first step in the inquiry has been completed.

7.2.2 Force Structure Impacts

The next challenge is to measure the effect of the proposed transfers on the Jordanian air defense force structure. To accomplish this task, additional information needs to be extracted from the data set and modified in accordance with inquiry objectives. First, alternative air inventories must be formulated. According to a least one report, the first F-20s could be delivered within 2.5 years of a decision, with the full package in place within 5.5 years. Initial F-16CSC deliveries would be delayed an additional year. Information concerning Mirage-2000C production schedules was not available, so it was assumed first deliveries could take place within three years of an order. For the sake of the illustration, it was postulated that all deliveries would be completed by 1990, a risky assumption in the case of the F-16CSC, but one which is suitable to the demonstration. In deference to data base limitations, it will be assumed that the notional analysis is being conducted in response to the initial request, with a decision anticipated before the end of 1985.

Based on the above, F-20's were introduced into the Jordanian inventory begining in 1988, with all 40 delivered by 1990. All 40 F-16CSC's were also forecast to be in place by the end of that year, as were all the Mirage-2000C's, the delivery of which would have begun in 1989. The results of the force level computations are displayed in Table 7.3 Again, a couple of reminders might be useful. The capabilities embodied in the transfers under study are integrated into a pre-existing force structure, so the Air Combat Potential Unit ratings constitute aggregated totals. Additionally, the force level computations include a sortie generation algorithm which considers an aircraft's maintenance requirement (man maintenance hours/flying hour) and mission specific sortie lengths. Consideration of these factors creates even greater differentiation among the options than was exhibited when the sterile air weapon system ratings were examined.

Regarding this table, additional dimensions of the assessment process come into focus. First, the earlier availability of the F-20, if accurate, provides a more immediate payoff. Second, the low maintenance overhead associated with the F-20 permits a higher sortie generation rate which more than compensates for the higher weapon system scores received by the Mirage-2000C. On the basis of this force level analysis, it appears that the F-20 represents the most effective air-to-air combat choice for the Royal Jordanian Air Force, even when the French option is considered.

Table 7.3: Jordanian Air-to-Air Combat Potential - Options

	1988	1989	1990
F-16CSC Package			
Air Defense	45.67	45.67	100.34
Fighter	32.35	32.35	82.71
Total Air-to-Air	78.02	78.02	193.05
F-20 Package			
Air Defense	78.14	109.93	152.32
Fighter	57.24	81.96	114.92
Total Air-to-Air	135.38	191.89	267.24
Mirage-2000C Package			
Air Defense	45.67	100.92	137.30
Fighter	32.35	64.46	85.76
Total Air-to-Air	78.02	165.38	223.06

Note: Computation used unmodified data and system defaults

7.2.3 Modifying Assumptions and Packages

7.2.3.1 Alternate Assumptions

Upon reviewing these results, the user might again decide that some of the input data need further revision. For instance, it could be observed that the maintenance requirement for the F-20 (15 MMH/FH) is not derived from an evaluation of fielded systems and might be overly optimistic and that the F-16CSC estimate (23 MMH/FH) is a bit pessimistic.[5] Consequently, the maintenance figure for the F-20 could be raised to match user perceptions and the F-16CSC estimate lowered. Table 7.4 displays the results of a computation when the maintenance requirement for the F-20 is raised by four hours and that for the F-16CSC is lowered by two. The recomputation places the F-16CSC in a more competitive position in the 1990 time frame with the Mirage-2000C, although the F-20 still enjoys a definite advantage.

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5 This statement in no way is meant to impugn the estimates made by any aircraft producer. These variations are included solely to demonstrate methodological flexibility.

Table 7.4: Jordanian Air-to-Air Combat Potential - Revised

	1988	1989	1990
F-16CSC Package			
Air Defense	45.67	45.67	120.98
Fighter	32.35	32.35	86.01
Total Air-to-Air	78.02	78.02	206.99
F-20 Package			
Air Defense	75.91	106.15	146.47
Fighter	53.56	74.78	103.07
Total Air-to-Air	129.47	180.93	249.54
Mirage-2000C Package			
Air Defense	45.67	98.30	133.39
Fighter	32.35	64.54	85.99
Total Air-to-Air	78.02	162.84	219.38

Note: Computation used modified airframe and force level data.

7.2.3.2 Alternate Package Composition

On the basis of these preliminary findings, it could be hypothesized that the F-20 package merits additional evaluation. Table 7.5 portrays the impact of the 40 aircraft F-20 package on overall Jordanian force potential, this time including the air-to-ground assets. Jordanian interdiction and close air support capabilities are provided primarily by 56 F-5E's. CASA C-101's (14) join the inventory beginning in 1988 to accomplish the counterinsurgency mission, which is subsumed into close air support in these calculations. The calculations used in compiling this and subsequent tables incorporate the assumption and data revisions postulated earlier.

Table 7.5: Jordanian Air Combat Potential

	1988	1989	1990
Air Defense	75.91	106.15	146.47
Fighter	53.56	74.78	103.07
Interdiction	43.73	44.45	44.45
Close Air Support	152.29	158.12	158.12
Total	325.50	383.50	452.11

For the sake of this demonstration, an assumption could be made that proposal of a 40 aircraft package would be politically inopportune but that a smaller complement might be palatable. Recognizing

Jordan's precarious security situation, it might be advisable to couple the reduced package with assurances of American support in case of Syrian aggression. While this hypothesis is a bit far-fetched politically, it would reduce Israeli sensitivities to the proposal while bolstering Jordanian confidence. A tentative security package was envisioned which would limit the number of aircraft to 24 but which would pledge American air refueling support for air defense missions and supplementary maintenance support for all F-20's in the case of war with Syria.[6] Under this proposal, 12 F-20's would be delivered in 1988, with an additional 12 the following year, mirroring the original delivery proposal. No further deliveries would be accomplished. The results of this notional formulation on Jordanian air combat potential are depicted in Table 7.6.

Table 7.6: Jordanian Air Combat Potential - U.S. Support

	1988	1989	1990
Air Defense	87.02	123.05	123.05
Fighter	56.32	80.29	80.29
Interdiction	43.73	44.45	44.45
Close Air Support	152.29	158.12	158.12
Total	339.36	405.91	405.91

The impact of aerial refueling and supplementary maintenance (20%) support can be seen most clearly in the air defense scores for 1988 and 1989. Potential air defense combat output in each of these years is significantly enhanced by the combined effects of increased endurance and greater maintenance resources. Fighter mission capabilities are less noticeably affected, since tankers would not be committed to support air superiority missions. However, the figures in the 1990 column indicate that these support enhancements will not fully compensate for an inventory reduced by 40 percent, even though they do make a dent in the potential deficit.

In realistic terms, this particular security assistance arrangement might be a pipe-dream, but the potential to evaluate such complex hardware and support combinations is inherent in the analytical methodology. One more flexibility exercise will be conducted before moving to the regional stability issue. Acknowledging that Jordan is confronted with a relative deficit not only in air defense assets but also in ground attack resources, a final question is to evaluate the impact of the contemplated F-20 transfer insofar as it would permit the Jordanian Air Force to shift other assets to ground attack missions. Specifically, the F-20's might conceivably replace the current contingent of Mirage F-1's in the air-to-air

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6 According to the manufacturer, the F-20 can be equipped with an optional refueling probe.

missions, with the latter re-roled as ground attack assets. Table 7.7 depicts the results of that investigation.

Table 7.7: Jordanian Air Combat Potential - F-1's Re-roled

	1988	1989	1990
Air Defense	75.91	60.48	100.80
Fighter	53.56	42.43	70.72
Interdiction	43.73	64.37	64.37
Close Air Support	152.29	207.12	207.12
Total	325.50	374.40	443.01

In this instance, the 37 F-1C/E's were reassigned to air-to-ground missions in 1989 after the first 24 F-20's had become available for air-to-air operations. Note the substantial drop in air defense and fighter capabilities in 1989 which is only partially rectified with the arrival of 16 additional F-20's in 1990. At the same time, Jordan's interdiction potential would increase by approximately 50 percent, with close air support capabilities climbing a more modest 25 percent. Given the Jordan's vulnerability to air attack and the relative superiority of its neighbors, such a conversion would be unlikely, but its effects can be forecast.

7.2.4 Assessing Regional Stability

Of course, force potential computations are only of passing interest when viewed outside their employment context. The next series of assessments places a proposed 40 aircraft F-20 sale to Jordan in two threat environments. The first assesses the relative combat balance between Jordan and its allies against its most threatening neighbor, Syria.

7.2.4.1 Jordan and Allies Versus Syria

At the outset, it is important to recollect that the ratings represent the balances of relative potential for a single day of combat. They are unmodified by considerations of operational proficiency or C^3I support and should in no way be construed as predictors of combat outcome. They are static rather than dynamic indicators of potential combat effectiveness. To further explore system capabilities, it will be assumed that Saudi Arabia and Iraq will provide Jordan limited air support in a confrontation with Syria. Amman's notional allies will retain all air-to-air assets for their own protection and will contribute a portion (Iraq, 50%, Saudi Arabia, 30%) of their interdiction resources for attacks against Syria. No allied close air support assets will be considered, since the command and control difficulties involved are be prohibitive. The balance of air combat potential under this scenario is shown in Table 7.8.

Table 7.8: Jordanian/Syrian Air Combat Balance - Allied Support

	1988	1989	1990
Jordan and Allies			
Air Defense	75.91	106.15	146.47
Fighter	53.56	74.78	103.07
Interdiction	60.66	60.66	60.66
Close Air Support	152.29	158.12	158.12
Syria			
Air Defense	439.14	434.23	544.74
Fighter	326.21	310.59	347.32
Interdiction	68.55	69.40	65.60
Close Air Support	190.29	192.93	181.34

Syria's preponderant superiority in air-to-air combat potential is clearly demonstrated. Its air-to-ground potential is considerably more modest, virtually on a par with that of Jordan and its allies. However, the comparisons which really count in this evaluation are those between the mission roles. Syrian air defense forces have such a significant combat potential that the relatively weak interdiction effort which Jordan and its allies could launch would not likely be any more than marginally effective from a military standpoint. Similarly, the probability of Jordan maintaining air superiority over the battlefield would be remote, given the overwhelming Syrian superiority in the fighter mission category. The inability to credibly contest Syrian air superiority would severely curtail the potential effectiveness of Jordan's close air support assets, even though they are on a relative par with Syria's. On the plus side, the combination of Jordan's bolstered air defense potential and Syria's low interdiction potential distinctly diminishes the air threat against key targets within Jordan. All other factors being held constant, the addition of advanced aircraft to Jordan's air defense arsenal might well deter a Syrian air attack but would still not be sufficient to carry the air war to Syria or to offset Syrian ground force superiority.

7.2.4.2 Jordan and Allies Versus Israel

A second threat environment which must be adressed, albeit reluctantly, involves war between the Arab Confrontation States and Israel. The first problem is to define which states fit in the Confrontation category, and the composition is by no means clear. Since the study is concerned with military potential and not rhetoric, the Arab posture will be construed less effusively than is sometimes the practice. Syria is the Arab hub; and Jordan will be included only insofar as the assessment concerns the impact of arms sales to it. Additionally, Iraq and Saudi Arabia will be assumed to contribute the same level of support as was postulated in the previous scenario against Syria. With Egypt militarily and politically neutralized by the Camp David Accord, this line-up seems to constitute the least unreasonable of the potential threats to

Israel.[7]

Table 7.9: Arab/Israeli Air Combat Balance

	1988	1989	1990
Jordan and Allies			
Air Defense	526.16	494.71	645.56
Fighter	382.53	353.02	418.04
Interdiction	165.86	187.28	183.48
Close Air Support	342.58	400.13	388.46
Israel			
Air Defense	658.01	669.14	646.84
Fighter	428.10	434.92	419.70
Interdiction	331.95	328.01	363.10
Close Air Support	797.91	780.51	746.92

Looking at Table 7.9, combined Syrian and Jordanian air-to-air combat potential will approach that possessed by Israel at the end of the decade.[8] Relative parity in the air-to-air roles would be predicated on Syria's acquisition of four squadrons of MiG-29's and two squadrons of SU-27's by 1990 and Jordan's receipt of the F-20 arms package. Israel will continue to hold a clear edge in air-to-ground mission potential, compensating for numerical inferiority on the ground. Evaluating the situation across mission areas, the picture is less clear. The Arab potential to conduct successful interdiction operations against Israel proper in the face of the IAF's substantial air defense capability is negligible.[9] In the same regard, evolving Arab air defense potential might attenuate the hitherto unchallenged Israeli potential to conduct deep interdiction operations at will. Over the battlefield, air superiority potential would suggest a virtual standoff if other factors such as pilot skill, maintenance proficiency, and C^3I are held constant. Even when this matchup is deemed a wash, Israeli capabilities to provide air support to ground forces measurably outstrip Arab potential to do the same. In a final comment, the organization and training of the Israeli Air Force give it considerably greater flexibility in asset allocation. With F-16's, F-4's, and, to a lesser degree, F-15's assigned to units with multi-role responsibilities, assets can be employed in combinations tailored to a particular threat scenario rather than according to the static allocations used in this par-

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7 From a political vantage point, the inclusion of Iraq and Saudi Arabia in a collegial effort with Syria is improbable. From a military perspective, Jordan's participation would be suicidal with Egypt on the side-lines. This example is illustrative only, not predictive or even plausible.

8 In this an other force level examples, the reader will note that total combat potential actually decreases in some years. The seemingly counterintuitive observation is a function of the replacement logic which decrements obsolete aircraft in unit sized increments *after* new acquisitions become available. When tabluated annually, this procedure creates some inventory overlaps which would disappear if inventories were tabulated on a monthly or quarterly basis

9 Recognizing the Arab deficit in interdiction assets, Jordanian Mirage F-1's are committed to air-to-ground roles in this assessment of the threat to Israel.

ticular computation.[10] For instance, multi-role fighter could be withdrawn from the air defense mission to gain air superiorty or to launch massive interdiction campaigns if the combat situation warranted.

To insert the impact of another dimension, quality of maintenance support, Table 7.10 depicts the same force balance when sortie generation potential is depreciated for relative support personnel proficiency. While the specific support index values might be challenged, there is no serious argument that Arab maintenance capabilities are on a par with Israel's. As can be seen from Table 7.10, the relative balance between the IAF and the combined Syrian and Jordanian Air Forces disintegrates when support personnel quality is considered. A further diminution of Arab potential would surely result from any appraisal which considered operator and C^3I proficiency as well, either quantitatively or subjectively.

Table 7.10: Arab/Israeli Air Combat Balance - Depreciated

	1988	1989	1990
Jordan and Allies			
Air Defense	344.77	365.08	473.70
Fighter	251.56	256.92	303.39
Interdiction	140.47	127.84	138.53
Close Air Support	317.62	324.75	315.70
Israel			
Air Defense	658.01	669.14	646.84
Fighter	428.10	434.92	419.70
Interdiction	331.95	328.01	363.10
Close Air Support	797.91	780.51	746.92

7.2.5 Conclusions

This string of analyses demonstrates the responsiveness of the proposed methodology in analyzing the military aspects of a security assistance case under a variety of assumptions. The model proved useful in assessing the relative merits of system alternatives, defining their impact on force structure, and evaluating their effect on stability in a regional context. Most importantly, the potential for user interaction at each phase of the process was exercised, altering computational inputs to accommodate differing perceptions or priorities. In this light, analytical output constitutes a flexible and comprehensive input to the interpretation and deliberation process.

Using the findings from this hypothetical example, for instance, one might observe that the transfer of a package of 40 F-20's configured for air-to-air operations is the most effective practicable response to Jordan's requirement for a modern air defense fighter. The F-20's would create the potential by 1990 to defend against Syrian air attacks on the vulnerable Jordanian heartland while not providing sufficient

10 Those allocations can be changed within the model to reflect differing threat perceptions, although this was not done in the current example.

capabilities to support offensive Jordanian air operations against either Syria or Israel. The sole threat such a transfer appears to pose to Israel is to diminish the potential effectiveness of Israeli interdiction operations. When depreciating factors such as the quality of maintenance support are considered, even this impact on Israeli security is negligible.

It goes without saying that these quantitatively based observations are insufficient evidence on which to predicate a transfer decision. Rather, they must be melded with assessments of other military factors such as ground based air defense capabilities, ground force combat potential, and a basket of international and domestic political considerations before a comprehensive policy can be elicited. Nevertheless, the type of quantitative military analysis capability demonstrated here is an essential element in the process. This fact demands that it be firmly grounded technically and methodologically, be visible to and accessible by the user, be adaptable to alternate configuration and computational assumptions, and capture the impact of security assistance programs on recipient combat potential output and regional balances. As illustrated, this methodology meets the demand.

7.3 Other Applications.

Throughout most of this investigation, the spotlight has been on the development and application of an assessment tool to assist arms transfer policy makers. It would be remiss, however, not to mention some additional applications to which it could be adapted.

7.3.1 Air Intelligence Analysis

The same features which make the methodology viable from a policy assistance standpoint are germane to some aspects of air intelligence analysis. There is no doubt that its focus on combat potential permits a more relevant portrayal of air capabilities evolution than does an analysis tethered exclusively to inventories. The ability to consolidate the combined influences of aircraft attributes and subsystems is even more valuable. The cumulative effects of the strengths and weaknesses of an air weapon system's parts are assessed all too infrequently in intelligence analyses which are boresighted on a handful of system characteristics. In the same vein, the impact on combat potential of upgrades to aircraft subsystems can be evaluated discretely or at the force level, as can alterations to force specific attributes such as mission allocation or maintenance support. The iterative capability is likewise pertinent to the process of estimating future threats under a variety of scenarios and force structures. As in the case of arms transfer policy assistance, the methodology is not sufficient in and of itself to capture the full range of factors which determine threat. However, it provides exponentially more comprehensive input data to the threat assessment process than does a mere listing of orders of battle and isolated performance characteristics.

7.3.2 Operations Research/Analysis

Standing alone, the methodology lacks the element of dynamic interaction inherent in most operations analysis models. While the latter are capable of stepping through multiple series of force on force combat simulations, many rely on categorical or nominal input data. Since force quality is an integral element in most operations analyses, system and force specific combat potential values generated by a methodology such as the one proposed in this study could supplant nominal measures at the front end. While no feasibility tests of this application have been conducted, it appears to be a productive avenue for additional inquiry.

7.3.3 Microcomputer Processing

Throughout the discussion, several substantive and procedural defects in the air combat potential methodology have been flagged as requiring further development. One additional deficiency is the fact that the model as currently constituted is cumbersome to operate. It was constructed on an IBM 3033 mainframe computer, using the Statistical Package for the Social Sciences (SPSS) processing system. While this combination provides a powerful and flexible processing environment, input data and combinational algorithms are not readily accessible to or modifiable by the casual user. For instance, each of the analytical iterations described in the previous section required reprogramming of the logic and utility values in several different computational modules. The procedure is effective but demands intimate familiarity with the data sets, access procedures, and programs. To that extent, system transparency is beclouded. Initial tests on data sub-sets suggest that the system could be installed profitably on a microcomputer outfitted with data base management and spreadsheet software.

Conceptually, a hierarchy of menu-like screens could channel processing in the direction(s) desired by the user and make the information which he required for a specific inquiry immediately available. Using dBase-II as a test vehicle, a series of menu screens were constructed, the options listed in which linked the user to specific data files. Files were arranged to correspond to the progression of analytical nodes described in Chapter 3 (e.g., airframe, target acquisition system, inventory). Employing the file edit capability, input data could be altered and sub-sets reserved for eventual introduction into the computational (spreadsheet) phase. Computational variables (e.g., relative utility variables, modifying variables) were established as 'look-up' tables in the spreadsheet (LOTUS 1-2-3) and could be inspected and altered by the user prior to score calculation.

In execution, these procedures proved conceptually sound but tedious and at times frustrating. User visibility and interaction were enhanced, and the requirement to delve into specific programs was eliminated. However, processing was limited to segmented data sets and required the linking of several spreadsheets. Values for computational variables could be changed with relative ease, but evaluating dif-

fering configurations or force alternatives required reinitiation of the entire problem definition process. In effect, the breadboard micro-based model proved only marginally more 'user-friendly' than the original system and was more time consuming. One additional deficiency stemmed from the fact that factor scoring could not be accomplished using the system configuration available. To add a new system or subsystem to a microcomputer file required regeneration of the expanded file on the mainframe system with results downloaded to the micro.

Several of the problems experienced in attempting to adapt the analytical methodology proceeded from the technical limitations inherent in the micro itself (Z-100 with 192K, no hard disk). Others undoubtedly reflect the researcher's relative unfamiliarity with applicable micro software. Given these factors, it would be imprudent to abandon the effort to adapt a version of this methodology for microcomputer operation. With a more powerful processor and more flexible data base management software, the creation of a truly user-interactive analytcial system is eminently achievable.

Chapter 8
SUMMING UP

The objective of this research effort has been to develop a methodology which permits the assessment of the aggregated impact of air weapon systems transfers on recipient air combat potential and regional military balances. At the outset, it was established that a viable methodology would have to meet six criteria:

- The methodology must be oriented toward combat relevant output not system input.
- The contribution of weapon subsystems to combat potential must be addressed.
- Comparison between aircraft in definable mission roles and among aggregated national forces is essential.
- Input data must be valid, accessible, and free from bias.
- Analytical procedures must be transparent and purged of sources of systemic error.
- Analytical assumptions must be clearly delineated and amenable to user designated variation.

8.1 Analytical Structure

To insure compliance with the first three criteria, a matrix was developed the key elements of which constitute the components implicated in assessing force air combat capability. Two essential elements, air weapon system performance and force propagation potential, were positioned at the apex of the framework. They were divided into the subcomponents which define their basic dimensions. Along with the various categories of subsystem, the air weapon system performance group included a family of factors which related the subsystems in terms of configuration and combat utility. On the force propagation side of the ledger, inventory, mission allocation, and sortie generation subcomponents were identified. The importance of intangible factors such as operator proficiency and C^3I support was acknowledged but their consideration deferred to other research efforts. Each subcomponent thus identified was further divided into the performance attributes which contribute to its operation. These were in turn subdivided into the variables which describe those attributes.

8.2 Data Collection

The articulated analytical structure constituted the data collection matrix. While absolute validity was compromised by the requirements to consider only unclassified data and to estimate values for some unknowns, multiple sources were cross checked to develop the most accurate values possible. When data

were unavailable, they were estimated using the most accurate technique which could be supported. In some instances, specific data values are consequently open to challenge. While the inaccuracies are lamentable, they are not fatal to the evaluation technique itself and can easily be revised in subsequent applications. Measurement biases were minimized by closely scrutinizing observation conditions and adjusting reported values to a common measurement plane. Certain artifical constraints were established to expedite the process. Only fixed wing aircraft with direct combat application in recent or future Middle Eastern combat scenarios were considered. Since the methodology aimed to support the development of future arms transfer policies, national air combat inventories were anchored with known data from the past two years and projected out to 1990.

The final air weapon system data set consisted of performance and configuration data on 125 aircraft and aircraft variants, 52 target acquisition systems, 41 air-to-air missiles, and 36 aerial guns. The configuration data set mated subsystems to aircraft and addressed those performance relevant characteristics (e.g., navigation system) for which quantitative values were not available. A unique data set was collected to determine the relative utilities of attributes and subsystems in definable combat roles. A panel of 25 fighter experts familiar with Middle Eastern air operations was polled to ascertain their views on the relationships which obtain among attributes and subsystems in four different mission areas. The results were synthesized statistically and recast as relational variable values to be employed during the weapon system combinational phase.

8.3 Data Aggregation

To identify a data reduction and aggregational methodology which produced the most comprehensive results uninfluenced by systemic bias, off-the-shelf aggregational methodologies were evaluated to identify their assets and liabilities. Factor analysis stood out because of its ability to consolidate multiple variables into common attribute performance measures. However, its combinational logic is haphazard when applied at the weapon system level, and its output measures are not legitimate candidates for aggregation at the force level. Multi-attribute utility technique produces a judgment based combinational matrix but is administratively unweildly and naturally applicable only to ratio level data. The weighted linear aggregation technique developed by The Analytic Sciences Corporation incorporates expert judgment and processes data of any measurement level but cannot accommodate multi-variable attributes and is insensitive to performance variations within broadly defined subsystem categories. Whatever its strengths or weaknesses, each methodology demonstrated the criticality of solid and comprehensive data input to the production of meaningful results.

Capitalizing on the strengths of existing approaches, a hybrid methodology for data reduction and aggregation was implemented. Factor analysis was employed to create relative index values for attributes described by multiple variables. Targeted at the attribute level, this minimalist version of the factor analysis methodology purged the indices of extraneous variable influences. Ratio properties were restored to the indices through the utilization of a zero-valued control case the factor score for which constituted a threshold from which other scores in the data set could be scaled. Variables described by nominal values were not included in the factor problems to preclude their distorting influences but were reserved for introduction in the aggregation process.

The computational phase itself was adapted with a few major variations from the linear equations developed by The Analytic Sciences Corporation. The process was initiated at the bottom of the analytical ladder, combining subsystem attributes. Expert assigned values for nominally described variables were used to modify the raw attribute scores extracted from the data reduction phase. Attribute scores were combined in accordance with their relative air combat utilities in each mission area. An analogous procedure was followed at the subcomponent and component levels, with the computations not only considering relative utility values but also conforming to specific air weapon system configurations. The product is a set of relative combat potential scores (Air Combat Potential Units) for each of the 125 air weapons systems in whatever mission roles were appropriate.

Force propagation values were computed in a somewhat different fashion. National aircraft inventories, mission allocations, operational availability rates, maintenance requirements, and maintenance resources were considered in a series of equations which computed the sortie generation potential for each possessed air weapon system in those roles to which it would likely be committed. To illustrate the impact of personnel force quality on sortie generation, an additional force level factor, the relative support index, was also injected into selected force propagation equations. Since the variables on which the support index was predicated are considered 'soft' surrogates for personnel quality, its general application is not recommended. However, its profound influence testifies to the requirement for such intangibles to be considered objectively or subjectively in force propagation and air combat analysis.

In the ultimate computational step, air weapon system mission potential and national force propagation potential were mated to produce an estimate of a country's air combat potential in four mission roles on a single day of flying. All of the modifying and relative utility values involved in weapon system and force level calculations are explicit and can be modified by the model's user to reflect differing combat scenarios or priorities. This feature was installed to permit user visibility and control over methodological functions. This model is not a 'black-box'.

8.4 Results

The results of the aggregation phase were reviewed to determine their efficacy both at the air weapon system and national force levels. The results conformed to intuitive assessments and poignantly demonstrated the desirability of employing a analytical scheme which aggregates the cumulative effects of system and force subcomponents on specific mission outputs. To further exercise the model, a phased analysis of a specific arms transfer proposal (advanced air defense fighters for Jordan) was conducted. The model showed itself to be responsive to the type of modifications a decision maker might stipulate in evaluating specific weapon system alternatives, weighing their contribution to force capabilities under varying conditions, and analyzing their impact on regional military balances under differing conflict scenarios.

8.5 Evaluation

The air combat potential aggregation methodology proposed in this study is a powerful and flexible mechanism with which to analyze the composition, benefits, and liabilities of air weapon systems transfers individually and at the force and regional levels. However, the methodology is far from perfect possessing some drawbacks which are easily surmountable and others which might prove impervious to systematic solution. The most prominent strengths and weakness of the of the proposed model, arranged according to study criteria, are outlined below.

- Throughout, the focus on mission relevant combat output was maintained. However, the linear combinational form and the absence of key combat related intangibles produce results which are static indicators of undepreciated potential. According to the aircrew survey, technical potential determines approximately 35 percent of combat effectiveness. Consequently, model output cannot legitimately stand alone but must be incorporated with other analysis which addresses the the remaining 65 percent of the question.
- The model effectively captures the performance attributes of the most prominent aircraft subsystems and their relative combat utility under varying scenarios. In doing so, it permits the evaluation of specific configurations and subsystem alternatives. The picture could be further sharpened if equipment-specific quantitative values for electronic warfare equipment, air-to-ground ordnance, and fire control computers could be integrated.
- Methodological output is composed of ratio level measurements which can be aggregated into a virtually infinite variety of combinations to permit comparisons across any spectrum. However, the measurements are not absolute and are relevant only in relation to other values derived from the same data set and analytical model.

- The data reduction and aggregation methodology is transparent and free of crippling systemic bias. Two drawbacks are the requirement to reprocess data sets statistically to determine new relative attribute values as systems are added to the data set and the linear computational form noted in an earlier comment.
- Methological assumptions and limitations were underscored throughout the discussion. The more important assumptions are represented mathmatically in the computational equations and can be modified to accommodate revised assumptions or priorities. Given the prototype's processing environment, making these adjustments is at present a decidely complicated and 'user-unfriendly' task.

8.6 Suggestion for Further Development

The methodology's underlying philosphy, analytical framework, and combinational scheme are valid and extendable to other regions, categories of weapons, and analytical problems. But first some enhancements are required to shore up its validity and applicability.

- A classified data base should be created and expanded to include additional aircraft, subsytems, and regions. This process would obviate inaccuracies and permit application to other Thrid World regions.
- Analytical subsets addressing elements of the ground air defense environment could also be introduced into the model relatively painlessly to permit analysis of a complete air combat picture.
- A microcomputer based version of the analytical methodology should be developed permitting direct user interaction. The feasibility of a menu driven micro-based system has been demonstrated; so this objective can be readily realized given the appropriate equipment and software expertise.
- Of greater complexity is the development of algorithms which capture the synergy among system and force components. One possibility is to attempt adaptation of existing air combat simulations to define an alternative non-linear aggregational scheme.
- Integration of combat relevant intangibles is a similarly complex challenge. Reliable mathmatical representations might not prove possible, but the influences of operator proficiency and the like can be reasonably assessed by weapon system and regional experts and applied subjectively in interpreting model output.

8.7 Conclusion

The air weapon system potential model is not a predictor of combat outcomes, but it does provide the decision maker with finely textured and responsive static indicators of individual weapon system and force

potential. These indicators are essential points of departure in evaluating the military dimension of security assistance options. With the enhancements described above, the methodology developed in this research effort represents a productive vehicle for intelligence community participation in the security assistance policy development process.

Appendix A
FILE DESCRIPTIONS

A.1 Middle East Combat Aircraft File

VARIABLES ON THE ACTIVE FILE

NAME	DESCRIPTION
ACFT	AIRCRAFT NAME
ROLE	CATEGORY
	VALUE — LABEL
	BMAT — BOMBER-GROUND ATTACK
	FTAT — FIGHTER-GROUND ATTACK
	FTTA — FIGHTER/TRAINER-GROUND ATTACK
	FTIN — FIGHTER-INTERCEPTOR
	FTTI — FIGHTER/TRAINER-INTERCEPTOR
	FTMR — FIGHTER-MULTI ROLE
	FTTM — FIGHTER/TRAINER-MULTI ROLE
	FTRE — FIGHTER-RECONNAISSANCE
	FTTR — FIGHTER-TRAINER
	MIAT — MISCELLANEOUS-GROUND ATTACK
	MITA — MISCELLANEOUS/TRAINER-GROUND ATTACK
SPAN	WING SPAN (FT)
SURF	WING SURFACE (SQ FT)
ARWNG	WING ASPECT RATIO
EWGT	EMPTY WEIGHT (LBS)
MWGT	MAXIMUM TAKEOFF WEIGHT (LBS)
CWGT	COMBAT WEIGHT (LBS)
WLOAD	COMBAT WING LOADING (LBS PER SQ FT)
FWGT	INTERNAL FUEL (LBS)
FUFRAC	FUEL FRACTION
MAXPWR	MAXIMUM THRUST (LBS)
TWPWR	THRUST TO WEIGHT RATIO
ASPD	MAXIMUM AIRSPEED FL360 (KTS)
SPECENA	SPECIFIC ENERGY AT ALTITUDE (FPS)
PSFL100	EST SPECIFIC EXCESS POWER FL100 M.9
CSPD	CLIMB SPEED SEA LEVEL (FPM)
LSPD	MAXIMUM AIRSPEED SEA LEVEL (KTS)
SPECENS	SPECIFIC ENERGY AT SEA LEVEL (FPS)

SSPD	STALL SPEED (KTS)
LIMG	COMBAT G LIMIT
TURATE	EST TURN RATE AT SL (DEG PER SEC)
SCEIL	SERVICE CEILING (FT)
FRANGE	FERRY RANGE (NM)
CRANGE	COMBAT RANGE (NM)
AIRAD	AIR INTERCEPT RADIUS (NM)
GARAD	GROUND ATTACK RADIUS (NM)
NGUN	NUMBER OF INTERNAL GUNS
CAL	CALIBRE OF GUN(S)
ROUNDS	ROUNDS GUN ORDNANCE
STNS	NUMBER OF WEAPON STATIONS
MAXORD	MAXIMUM ORDNANCE (LBS)
VGW	VARIABLE GEOMETRY WING VALUE LABEL 1 YES 0 NO
VCW	VARIABLE CAMBER WING VALUE LABEL 1 YES 0 NO

A.2 Middle East Target Acquisition System File

VARIABLES ON THE ACTIVE FILE

NAME	DESCRIPTION
NAME	EQUIPMENT NAME
CODE	EQUIPMENT TYPE VALUE LABEL IRAI IR SEARCH-TRACK LAGA GROUND ATTACK LASER RAAI AIR INTERCEPT RADAR RAGA GROUND ATTACK RADAR RAMU MULTI-PURPOSE RADAR
PWR	OUTPUT POWER (KW)
CONE	SEARCH AZIMUTH (DEG)
UPRNG	RANGE-CO OR HI ALT TGT (NM)
DWNRNG	RANGE-LO ALT TGT (NM)
DATAPTS	DATA POINTS REPORTED
TWS	TRACK WHILE SCAN VALUE LABEL 0 NO 1 YES
ILLUM	CW ILLUMINATION VALUE LABEL 0 NO 1 YES
MAP	GROUND MAPPING VALUE LABEL 0 NO 1 YES
DBS	DOPPLER BEAM SHARPENING VALUE LABEL 0 NO 1 YES
ECCM	ECM SUSCEPTIBILITY RATING VALUE LABEL .7 VERY HIGH .8 HIGH .9 AVERAGE 1.0 LOW 1.1 VERY LOW

A.3 Middle East Air-to-Air Missile File

VARIABLES ON THE ACTIVE FILE

NAME	DESCRIPTION
MSL	MISSILE NAME
CODE	MISSILE TYPE VALUE LABEL AAMI AIR TO AIR-INFRARED GUIDED AAMR AIR TO AIR-RADAR GUIDED
PRODCC	PRODUCER COUNTRY CODE
DIAM	MISSILE DIAMETER (IN)
LENGTH	MISSILE LENGTH (IN)
MSLWGHT	MISSILE WEIGHT (LBS)
GUIDTYP	TERMINAL GUIDANCE MODE VALUE LABEL ARH ACTIVE RADAR CG COMMAND GUIDED EO ELECTRO OPTICAL IR INFRARED LASR LASER GUIDED SARH SEMIACTIVE RADAR
GUIDSC	GUIDANCE SCORE
WHWGHT	WARHEAD WEIGHT (LBS)
FUZE	NUMBER FUZE OPTIONS
MAXHRNG	MAXIMUM HEAD-ON RANGE (NM)
MINHRNG	MINIMUM HEAD-ON RANGE (NM)
MAXTRNG	MAXIMUM TAIL-CHASE RANGE (NM)
MINTRNG	MINIMUM TAIL-CHASE RANGE (NM)
MSPD	MAXIMUM SPEED (MACH)
LIMG	G LIMITATION
ECCM	ECM SUSCEPTIBILITY VALUE LABEL .7 VERY LOW .8 LOW .9 AVERAGE 1.0 HIGH 1.1 VERY HIGH
EFFHRNG	EFFECTIVE HEAD-ON RANGE
EFFTRNG	EFFECTIVE TAIL-CHASE RANGE
MODE	MISSILE LOCK-ON MODE VALUE LABEL VR VISUAL RANGE ONLY BVR BEYOND VISUAL RANGE

GIUDADX	GUIDANCE SCORE AIR DEFENSE
GUIDAS	GUIDANCE SCORE AIR SUPERIORITY

A.4 Middle East Aerial Gun File

VARIABLES ON THE ACTIVE FILE

NAME	DESCRIPTION
GUN	GUN DESIGNATOR
CODE	GUN TYPE VALUE LABEL AAAG ANTI-AIRCRAFT GUN ACCE ACFT CANNON EXTERNAL ACCI ACFT CANNON INTERNAL
PRODCC	PRODUCER COUNTRY CODE
CAL	CALIBRE (MM)
MRNG	MAXIMUM EFFECTIVE RANGE (NM)
DISP	DISPERSION (MILS)
MVEL	MUZZLE VELOCITY (FPS)
RATE	MAXIMUM RATE OF FIRE (SPM)

A.5 Middle East Air Weapon System Configuration File

VARIABLES ON THE ACTIVE FILE

NAME	DESCRIPTION
ACFT	AIRCRAFT NAME
CODE	AIRCRAFT TYPE
PRODCC	PRODUCER COUNTRY CODE
CREW	CREWMEMBERS
ARC	AIR REFUELING CAPABLE VALUE LABEL 0 NO 1 YES
NAVCAT	NAVIGATION CATEGORY VALUE LABEL DOP DOPPLER NAV SYSTEM DR DEAD RECKONING GPS GLOBAL POSITIONING SYSTEM INS INERTIAL NAV SYSTEM TAC TACAN TYPE SYSTEM
RWR	RADAR WARNING RECEIVER VALUE LABEL 0 NO 1 YES
PECM	PASSIVE ELECTRONIC COUNTERMEASURES VALUE LABEL 0 NO 1 YES
AECM	ACTIVE ELECTRONIC COUNTERMEASURES VALUE LABEL 0 NO 1 YES
AAMR	PRIMARY RADAR AAM
NAAMR	NUMBER RADAR AAM
AAMI	PRIMARY IR AAM
NAAMI	NUMBER IR AAM
GUN	INTERNAL GUN
PGMC	PRECISION GUIDED MUNITIONS CARRIER VALUE LABEL 0 NO 1 YES
SA	STABILITY AUGMENTATION VALUE LABEL 0 NO 1 YES
HUD	HEAD UP DISPLAY VALUE LABEL 0 NO 1 YES
CRP	RELEASE POINT COMPUTER

VALUE	LABEL
0	NO
1	YES

TARAD	RADAR TGT ACQ SYSTEM
TAOTH	SECONDARY TGT ACQ SYSTEM
MMHFH	MAN MAINTENANCE HOURS PER FLYING HOUR

A.6 Middle East Air Order of Battle 1984-1990

VARIABLES ON THE ACTIVE FILE

NAME	DESCRIPTION	
CC	COUNTRY CODE	
	VALUE	LABEL
	AG	ALGERIA
	BA	BAHRAIN
	EG	EGYPT
	ET	ETHIOPIA
	IR	IRAN
	IS	ISRAEL
	IZ	IRAQ
	JO	JORDAN
	KU	KUWAIT
	LE	LEBANON
	LY	LIBYA
	MO	MOROCCO
	MU	OMAN
	QA	QATAR
	SA	SAUDI ARABIA
	SO	SOMALIA
	SU	SUDAN
	SY	SYRIA
	TC	UNITED ARAB EMIRATES
	TS	TUNISIA
	YE	NORTH YEMEN
	YS	SOUTH YEMEN
ACFT	AIRCRAFT NAME	
EMCODE	LIKELY EMPLOYMENT ROLE	
	VALUE	LABEL
	BMR	BOMBER
	CIN	COUNTER-INSURGENCY
	FGA	FIGHTER-GROUND ATTACK
	FIN	FIGHTER-INTERCEPTOR
	FMR	FIGHTER-MULTI ROLE
	OCA	OPNL CONVERSION-AIR-TO-AIR
	OCG	OPNL CONVERSION-GROUND ATTACK
	OCM	OPNL CONVERSION-MULTIROLE
	REC	RECONNAISSANCE
	TNG	TRAINING
INV84	1984 INVENTORY	
INV85	1985 INVENTORY	
INV86	1986 INVENTORY	
INV87	1987 INVENTORY	
INV88	1988 INVENTORY	
INV89	1989 INVENTORY	
INV90	1990 INVENTORY	
MXRAT	MAINTENANCE MAN/ACFT RATIO	
OAR	OPERATIONALLY AVAILABLE RATE	

Appendix B
MIDDLE EAST AIR WEAPON SYSTEMS DATA

B.1 Airframes

ACFT	ROLE	SPAN	SURF	ARWNG	EWGT	FWGT	CWGT	MWGT
ALPHAMS1	FTTC	30	188	4.75	7374	3351	11805	16535
ALPHAMS2	FTAT	30	188	4.75	7749	3648	12328	17637
AMX	FTAT	29	266	3.18	13228	4409	19621	25353
A10A	FTAT	58	506	6.53	21541	10700	34062	50000
A37B	FTAT	36	184	7.01	6211	3448	10775	14000
A4H	FTAT	28	260	2.91	10100	5440	17120	23740
A4KU	FTAT	28	260	2.91	10100	5440	17120	23740
A4N	FTAT	28	260	2.91	10800	5440	18255	25390
A7E	FTAT	39	375	4.01	19127	10200	31727	42000
A7P	FTAT	39	375	4.01	19781	10200	32006	42000
BAC167	FTAT	35	214	5.83	6195	2203	8797	11500
CM170	FTTC	40	186	8.51	5093	1754	6135	7495
CM170I	FTTC	40	186	8.51	5093	1754	6135	7495
C101BB	FTAT	35	215	5.62	7606	4260	12216	12345
C101CC	FTAT	35	215	5.62	7606	4260	12216	12345
C101DD	FTTA	35	215	5.62	7606	4260	12216	12345
FA18L	FTMR	38	400	3.52	20860	10380	27432	52000
F104GCF	FTAT	22	196	2.47	14082	5819	20742	28000
F14AC	FTIN	38	565	2.58	39921	16200	50335	74349
F15A	FTMR	43	608	3.01	28000	11635	37212	56500
F15B	FTTM	43	608	3.01	28800	11635	38012	56500
F15C	FTMR	43	608	3.01	28000	13455	38122	68000
F15CFP	FTMR	43	608	3.01	28000	23205	43001	68000
F15D	FTTM	43	608	3.01	28800	13455	38922	68000
F15E	FTMR	43	608	3.01	28000	13455	37064	75000
F16A	FTMR	31	300	3.20	15586	6972	19824	35400
F16B	FTTM	31	300	3.20	16258	5787	19904	35400
F16C	FTMR	31	300	3.20	18259	6972	23127	37500
F16CSC	FTMR	31	300	3.20	18259	6972	22433	37500
F16D	FTTM	31	300	3.20	19059	6972	23927	37500
F16J79	FTMR	31	300	3.20	17780	6972	21954	35400
F20	FTMR	27	186	3.86	11220	5050	14433	27500
F20A	FTMR	27	186	3.86	11220	5050	15127	27500
F4CD	FTMR	38	530	2.78	28000	15614	37101	58000
F4EF	FTMR	39	530	2.80	30328	15630	39525	60630
F4MOD	FTMR	39	530	2.80	30328	20094	41761	69275
F5A	FTMR	25	170	3.77	8085	3166	10012	20576
F5B	FTMR	25	170	3.77	8361	3116	10263	20116
F5E	FTMR	27	186	3.83	9723	4063	12099	24722
F5F	FTMR	27	186	3.83	10576	4603	13222	25152
F86F	FTMR	37	288	4.78	10950	3910	12905	16180
G91Y	FTAT	30	195	4.46	8598	3736	12466	19180
HARMK80	FTMR	25	201	3.18	13000	5060	16282	26200
HAWK200	FTMR	31	180	5.28	8750	3000	10626	19000
HAWK50T	FTTA	31	180	5.28	8015	3060	10315	16200
HAWK60A	FTAT	31	180	5.28	8015	3060	12945	18890
HAWK60T	FTTA	31	180	5.28	8015	3060	10315	18890
HUNTER	FTMR	34	349	3.25	13270	3199	14870	24000
HUNTERT	FTTM	34	349	3.25	14070	3199	15670	24000
IL28	BMAT	70	655	7.57	28417	14450	42256	46734
JAGI04	FTAT	29	260	3.12	15432	7540	24452	34612

JAGI11	FTAT	29	260	3.12	15432	7540	24452	34612
JASTREB	FTAT	34	209	5.66	6217	2600	8727	11243
KFIRC2	FTMR	27	375	1.95	16060	5670	19715	35715
KFIRC7	FTMR	27	375	1.95	16060	5670	19695	35715
KFIRTC2	FTTM	27	375	1.95	16860	5670	20105	35715
LAVI	FTMR	29	350	2.34	15500	6000	19300	37500
LIGHTNG	FTIN	35	380	3.19	28000	12000	34660	50000
L29	FTTA	40	283	5.58	5027	1905	6200	7804
L39ZA	FTTC	31	202	4.75	8060	2122	10334	12346
MB326K	FTAT	33	208	5.24	5907	1568	8691	11475
MB326L	FTTA	33	208	5.24	5907	1568	8691	11475
MB339A	FTTC	36	208	6.10	6889	2425	10102	13000
MB339C	FTAT	36	208	6.31	7066	3523	10963	13558
MB339K	FTAT	36	208	6.31	7066	3523	10963	13558
MIG15BIS	FTMR	33	255	4.27	8115	2586	9408	11085
MIG15UTI	FTTC	33	222	4.91	7716	2586	9009	10766
MIG17F	FTMR	36	265	4.89	9220	2962	10701	13393
MIG19C	FTMR	30	269	3.41	12700	3721	14941	20062
MIG21C	FTIN	24	248	2.25	12440	4202	15301	19026
MIG21F	FTMR	24	248	2.25	12300	4300	15210	20723
MIG21JKL	FTMR	24	248	2.25	12300	4668	15394	20723
MIG21R	FTRE	24	248	2.25	12440	4300	15590	20863
MIG21UM	FTTM	24	248	2.25	13100	4300	16010	21853
MIG23B	FTMR	47	400	5.47	21250	12168	30064	41670
MIG23E	FTMR	47	400	5.47	21200	12168	28044	44312
MIG23F	FTAT	47	401	5.46	24250	12168	32534	44312
MIG23G	FTMR	47	400	5.48	21450	12168	29186	41670
MIG23UM	FTTC	47	400	5.47	22000	10300	29350	41000
MIG25	FTIN	46	612	3.43	44100	27000	63860	79800
MIG25R	FTRE	44	603	3.21	43200	27000	60700	73635
MIG25U	FTTI	46	612	3.43	44090	27000	63850	79800
MIG27DJ	FTAT	47	401	5.46	23787	12168	33179	39685
MIG29	FTMR	34	380	3.11	25000	8800	32242	37500
MIG31	FTIN	44	580	3.40	48115	27000	64457	90725
MIRF1A	FTMR	28	269	2.81	16314	7379	21710	32850
MIRF1B	FTTI	28	269	2.81	16314	7379	21710	32850
MIRF1C	FTMR	28	269	2.81	16314	7379	21502	32850
MIRF1E	FTMR	28	269	2.81	17857	7379	23045	33510
MIRIIIC	FTIN	27	375	1.94	13570	5039	17789	17637
MIRIIIE	FTMR	27	375	1.94	14570	5039	18332	17637
MIRIIIEI	FTMR	27	375	1.94	14570	5039	18346	17637
MIR2000C	FTMR	30	441	1.97	16535	6513	21188	36375
MIR2000R	FTRE	30	441	1.97	16535	5860	20090	36375
MIR2000T	FTTM	30	441	1.97	17235	6513	21888	36375
MIR3NG	FTMR	27	375	1.94	17000	5959	21478	32400
MIR4000	FTMR	39	786	1.98	24220	19539	35386	unk
MIR5DD	FTTA	27	375	1.94	15350	5842	22271	30200
MIR5DR	FTRE	27	375	1.94	14550	5842	21880	30200
MIR5D1	FTIN	27	375	1.94	14550	5842	18714	30200
MIR5D1E	FTIN	27	375	1.94	14550	5842	18867	30200
MIR5D2	FTAT	27	375	1.94	14550	5842	22101	30200
OV10D	MIAT	40	291	5.50	6893	1714	9550	14444
PRCA5	FTAT	32	301	3.36	14317	6356	19700	26455
PRCFT6	FTTM	30	269	3.39	12700	3432	14416	22045
PRCF6	FTMR	30	269	3.39	12700	3725	14943	22045
PRCF7	FTIN	24	248	2.25	12440	4202	15301	19026
PRCF7E	FTIN	24	248	2.25	12440	4202	15265	19026
RF4C	FTRE	38	530	2.78	29000	15164	36782	58000
RF5E	FTRE	27	186	3.83	10723	4603	13225	24722
SF260MW	MITA	27	109	6.91	1830	373	2347	2866
SF260TP	MITA	27	109	6.91	1654	403	2186	2866
SUPETEN	FTAT	32	306	3.27	14220	5428	19249	19259
SU20	FTAT	46	432	4.90	22050	8157	30539	39020
SU22	FTAT	46	432	4.90	22500	8580	32302	42330
SU25	FTAT	51	450	5.73	17250	10000	26660	36050
SU27	FTMR	48	500	4.51	39000	15500	48948	63500
SU7BMKL	FTAT	29	297	2.89	19040	5181	24381	29750
SU7U	FTTA	29	297	2.89	19000	5181	24341	29750

TA4EH	FTTA	28	260	2.91	10084	5440	16904	23724
TA4KU	FTTA	28	260	2.91	10900	5440	17720	24540
TORADV	FTIN	46	400	5.20	31500	15632	41392	60000
TORIDS	FTAT	46	400	5.20	31065	14000	47985	60000
TU16AG	BMAT	108	1772	6.58	82000	56870	130235	158730
TU22BD	BMAT	91	1451	5.69	80400	81600	147650	185000

ACFT	MAXPWR	TWPWR	ASPD	SPECENA	LSPD	SPECENS	CSPD	SCEI
ALPHAMS1	5952	.50	487	975.30	540	215.54	11220	4800
ALPHAMS2	5952	.48	487	975.30	540	215.54	11218	4800
AMX	11030	.56	700	1195.52	628	291.51	15000	5000
A10A	18130	.53	450	716.35	380	106.73	6000	3400
A37B	5700	.53	455	849.11	403	120.05	6990	4176
A4H	9300	.54	587	1071.36	548	221.97	8000	4900
A4KU	9300	.54	561	1032.63	548	221.97	8000	4800
A4N	11200	.61	583	1067.90	560	231.80	10300	4900
A7E	15000	.47	720	974.85	600	266.10	20000	3550
A7P	12200	.38	563	825.96	600	266.10	12000	3550
BAC167	3410	.39	410	791.19	391	113.00	5250	4001
CM170	2116	.34	392	613.58	378	105.61	3740	3000
CM170I	2116	.34	392	613.58	378	105.61	3740	3000
C101BB	3700	.30	430	803.34	373	102.84	3780	4000
C101CC	4700	.38	450	849.68	373	102.84	5300	4200
C101DD	4700	.38	450	849.68	373	102.84	5300	4200
FA18L	32000	1.17	1146	1887.41	730	393.90	60000	5500
F104GCF	15800	.76	1232	2088.58	690	351.91	50000	5800
F14AC	41800	.83	1342	2264.53	702	364.26	30000	5600
F15A	47860	1.29	1433	2601.18	700	362.19	50000	6500
F15B	47860	1.26	1433	2601.18	700	362.19	50000	6500
F15C	47860	1.26	1433	2601.18	700	362.19	50000	6500
F15CFP	47860	1.11	1433	2601.18	650	312.29	29000	6500
F15D	47860	1.23	1433	2601.18	700	362.19	50000	6500
F15E	54820	1.48	1433	2601.18	670	331.81	50000	6500
F16A	25000	1.26	1175	1853.83	793	464.82	50000	5000
F16B	25000	1.26	1175	1853.83	793	464.82	50000	5000
F16C	25000	1.08	1175	1853.83	793	464.82	50000	5000
F16CSC	25000	1.11	1175	1853.83	793	464.82	50000	5000
F16D	25000	1.04	1175	1853.83	793	464.82	50000	5000
F16J79	18000	.82	1146	1804.08	687	348.86	50000	5000
F20	17000	1.18	1146	1887.41	694	356.00	52800	5500
F20A	17000	1.12	1146	1887.41	694	356.00	52800	5500
F4CD	34000	.92	1275	2201.59	773	441.67	28000	6000
F4EF	35800	.91	1301	2230.26	787	457.81	28000	5875
F4MOD	41200	.99	1301	2230.26	787	457.81	28000	5875
F5A	8160	.82	802	1325.43	635	298.05	28700	5100
F5B	8160	.80	768	1285.97	635	298.05	28700	5100
F5E	10000	.83	934	1508.14	661	322.95	34500	5180
F5F	10000	.76	894	1440.76	661	322.95	32890	5100
F86F	5970	.46	670	1215.14	650	312.29	17700	5300
G91Y	8160	.65	544	902.08	600	266.10	17000	4100
HARMK80	21500	1.32	739	1257.00	641	303.71	20000	5120
HAWK200	5700	.54	688	1183.21	560	231.80	1200	5000
HAWK50T	5340	.52	575	1077.72	535	211.57	11800	5000
HAWK60A	5700	.44	575	1077.72	560	231.80	11800	5000
HAWK60T	5700	.55	575	1077.72	560	231.80	11800	5000
HUNTER	10000	.67	622	1202.63	621	285.05	17500	5500
HUNTERT	10000	.64	622	1202.63	621	285.05	17500	5500
IL28	11904	.28	434	811.72	432	137.94	2952	4035
JAGI04	16800	.69	917	1621.55	729	392.82	26100	6000
JAGI11	18540	.76	917	1621.55	729	392.82	28000	6000
JASTREB	3000	.34	422	787.88	408	123.04	4135	3937
KFIRC2	17900	.91	1317	2248.73	750	415.78	45930	5800
KFIRC7	18900	.96	1317	2248.73	750	415.78	45930	5800
KFIRTC2	17900	.89	1317	2248.73	750	415.78	45930	5800
LAVI	20620	1.07	1060	1797.18	597	263.44	30900	5800
LIGHTNG	32600	.94	1318	2284.01	700	362.19	50000	6000
L29	1960	.32	353	592.11	332	81.47	2755	3000
L39ZA	3792	.37	373	704.50	340	85.45	4130	3610
MB326K	3360	.39	470	813.81	460	156.41	6494	3903
MB326L	3360	.39	470	813.81	460	156.41	6494	3903
MB339A	4000	.40	441	943.75	485	173.87	6595	4800
MB339C	4450	.41	441	902.09	490	177.47	6550	4550
MB339K	4450	.41	441	902.09	490	177.47	6550	4550
MIG15BIS	5952	.63	582	1097.92	567	237.63	10400	5085

MIG15UTI	5450	.60	565	1085.96	549	222.78	10400	510
MIG17F	7400	.69	570	1147.82	545	219.55	8000	544
MIG19C	14200	.95	779	1427.30	628	291.51	15000	587
MIG21C	12677	.83	1031	1742.36	600	266.10	21000	574
MIG21F	13688	.90	1159	1949.56	650	312.29	25900	574
MIG21JKL	14550	.95	1177	1980.64	680	341.79	30000	574
MIG21R	13688	.88	1159	1949.56	650	312.29	25900	574
MIG21UM	14550	.91	1177	1980.64	675	336.78	30000	574
MIG23B	27350	.91	1290	2246.70	727	390.67	50000	610
MIG23E	27350	.98	1290	2230.03	727	390.67	50000	600
MIG23F	23350	.72	974	1701.22	629	292.44	50000	600
MIG23G	27500	.94	1318	2284.01	727	390.67	50000	600
MIG23UM	22485	.77	1280	2227.70	661	322.95	50000	610
MIG25	50020	.78	1616	3263.61	650	312.29	40950	800
MIG25R	50020	.82	1616	3406.61	650	312.29	40950	885
MIG25U	50020	.78	1616	3263.61	650	312.29	40950	800
MIG27DJ	25350	.76	974	1576.22	629	292.44	40000	525
MIG29	38000	1.18	1318	2367.34	793	464.82	50000	650
MIG31	61730	.96	1500	2746.44	750	415.78	45000	650
MIRF1A	15873	.73	1261	2268.68	693	354.98	47835	656
MIRF1B	15873	.73	1261	2268.68	693	354.98	47835	656
MIRF1C	15873	.74	1261	2268.68	693	354.98	47835	656
MIRF1E	15873	.69	1433	2680.35	793	464.82	59000	697
MIRIIIC	13225	.74	1261	2104.93	734	398.22	16400	557
MIRIIIE	13670	.75	1261	2104.93	754	420.22	16400	557
MIRIIIEI	13670	.75	1261	2104.93	754	420.22	16400	557
MIR2000C	19840	.94	1347	2324.47	793	464.82	49000	590
MIR2000R	19840	.99	1318	2267.34	777	446.25	47429	590
MIR2000T	19840	.91	1347	2324.47	793	464.82	49000	590
MIR3NG	15873	.74	1261	2075.35	734	398.22	20000	540
MIR4000	42770	1.21	1318	2377.34	600	266.10	65600	656
MIR5DD	13670	.61	1261	2104.93	800	473.06	16400	557
MIR5DR	13670	.62	1261	2104.93	800	473.06	16400	557
MIR5D1	13670	.73	1270	2121.77	800	473.06	16400	557
MIR5D1E	13670	.72	1270	2121.77	800	473.06	16400	557
MIR5D2	13670	.62	1261	2104.93	800	473.06	16400	557
OV10D	2500	.26	250	546.20	250	46.20	3020	300
PRCA5	14330	.73	774	1276.14	721	384.24	15000	500
PRCFT6	14330	.99	720	1361.93	641	303.71	30000	587
PRCF6	14330	.96	720	1258.06	641	303.71	30000	524
PRCF7	12677	.83	1031	1742.36	535	211.57	21000	574
PRCF7E	12677	.83	1031	1742.36	535	211.57	21000	574
RF4C	34000	.92	1275	2180.76	773	441.67	28000	587
RF5E	10000	.76	894	1454.09	661	322.95	34500	518
SF260MW	475	.20	235	285.82	165	20.12	1250	147
SF260TP	505	.23	235	507.49	216	34.49	2170	280
SUPETEN	11265	.59	573	992.69	648	310.37	24600	450
SU20	24700	.81	1220	2084.33	680	341.79	45275	590
SU22	25350	.78	1220	2084.33	680	341.79	45275	590
SU25	18000	.68	475	750.11	380	106.73	6500	350
SU27	60000	1.23	1350	2347.11	725	388.52	50000	600
SU7BMKL	19841	.81	896	1421.74	450	149.68	29500	497
SU7U	19841	.82	896	1421.74	450	149.68	29900	497
TA4EH	8500	.50	596	1079.23	550	223.59	8440	490
TA4KU	9300	.52	561	1032.63	548	221.97	8000	480
TORADV	33600	.81	1301	2084.43	793	464.82	30000	500
TORIDS	32000	.67	1261	2008.68	782	452.01	30000	500
TU16AG	41900	.32	535	884.07	530	207.63	13100	403
TU22BD	61800	.42	800	1473.06	600	266.10	22100	600

ACFT	LIMG	WLOAD	TURATE	PSFL100	SSPD	VCW	VGW
ALPHAMS1	9.00	62.66	21.79	175.86	116	0	0
ALPHAMS2	9.00	65.44	21.76	163.64	116	0	0
AMX	7.33	73.76	17.76	243.53	90	1	0
A10A	7.33	67.32	20.86	208.15	unk	0	0
A37B	7.33	58.59	17.72	168.65	75	0	0
A4H	7.33	65.85	17.74	193.08	unk	0	0
A4KU	7.33	65.85	17.74	193.08	unk	0	0
A4N	7.33	70.21	17.82	252.49	unk	0	0
A7E	6.50	84.61	15.62	183.59	unk	1	0
A7P	6.50	85.35	15.52	108.45	unk	1	0
BAC167	6.00	41.16	16.52	10.06	99	0	0
CM170	7.33	32.97	20.97	-66.22	unk	0	0
CM170I	7.33	32.97	20.97	-66.22	unk	0	0
C101BB	7.50	56.74	21.76	-4.70	88	0	0
C101CC	7.50	56.74	21.76	63.19	88	0	0
C101DD	7.50	56.74	21.76	63.19	88	0	0
FA18L	8.00	68.58	20.24	736.43	100	1	0
F104GCF	7.33	105.77	18.00	442.56	unk	0	0
F14AC	7.33	89.09	18.09	485.08	115	1	1
F15A	7.33	61.20	18.67	821.32	110	0	0
F15B	7.33	62.52	18.63	801.67	110	0	0
F15C	9.00	62.70	22.95	799.04	110	0	0
F15CFP	9.00	70.72	22.72	695.66	110	0	0
F15D	9.00	64.02	22.90	780.31	110	0	0
F15E	9.00	60.96	23.31	980.80	110	0	0
F16A	9.00	66.08	22.96	810.37	unk	1	0
F16B	9.00	66.34	22.95	806.69	unk	1	0
F16C	9.00	77.09	22.67	678.63	unk	1	0
F16CSC	9.00	74.78	22.72	703.09	unk	1	0
F16D	9.00	79.76	22.61	652.19	unk	1	0
F16J79	9.00	73.18	22.26	456.42	unk	1	0
F20	9.00	77.60	22.82	759.66	unk	1	0
F20A	9.00	81.33	22.74	719.67	unk	1	0
F4CD	7.00	70.00	17.36	531.41	unk	0	0
F4EF	7.00	74.58	17.35	529.72	148	1	0
F4MOD	7.00	78.79	17.44	602.60	148	1	0
F5A	7.33	58.89	18.07	425.33	unk	0	0
F5B	7.33	60.37	18.04	412.18	unk	0	0
F5E	7.33	65.05	18.08	447.99	124	1	0
F5F	7.33	71.08	18.00	400.42	136	1	0
F86F	6.00	44.82	14.37	80.59	unk	0	0
G91Y	7.33	63.86	17.87	303.04	125	0	0
HARMK80	7.80	80.96	19.94	882.33	na	1	1
HAWK200	8.00	59.16	19.38	194.89	unk	1	0
HAWK50T	8.00	57.43	19.36	175.20	unk	0	0
HAWK60A	8.00	72.08	19.26	139.90	unk	1	0
HAWK60T	8.00	57.43	19.40	204.14	unk	1	0
HUNTER	7.33	42.61	17.89	228.74	unk	0	0
HUNTERT	7.33	44.90	17.85	211.91	unk	0	0
IL28	4.00	64.56	9.30	-4.11	119	0	0
JAGI04	8.60	93.94	21.07	370.89	115	1	0
JAGI11	8.60	93.94	21.17	429.91	115	1	0
JASTREB	8.00	41.74	19.13	-19.13	85	0	0
KFIRC2	7.33	52.63	18.18	485.90	unk	0	0
KFIRC7	7.33	52.58	18.25	528.62	unk	1	0
KFIRTC2	7.33	53.67	18.16	474.30	unk	0	0
LAVI	9.00	55.17	22.65	626.13	unk	1	0
LIGHTNG	7.33	91.19	18.22	520.67	unk	0	0
L29	6.00	21.93	19.45	-188.71	71	0	0
L39ZA	5.20	51.05	16.39	27.56	90	0	0
MB326K	6.00	41.78	14.30	13.25	unk	0	0
MB326L	6.00	41.78	14.30	13.25	unk	0	0
MB339A	6.00	48.64	14.31	48.54	80	0	0
MB339C	6.00	52.78	14.32	69.97	82	0	0
MB339K	6.00	52.78	14.32	69.97	82	0	0
MIG15BIS	6.50	36.89	15.78	162.72	113	0	0

MIG15UTI	6.50	40.62	15.75	160.43	unk	0	0
MIG17F	6.50	40.38	15.85	220.46	114	0	0
MIG19C	8.00	55.54	19.93	449.88	unk	0	0
MIG21C	8.00	61.80	19.77	398.72	unk	0	0
MIG21F	8.00	61.43	19.87	451.33	unk	0	0
MIG21JKL	8.00	62.17	19.93	486.52	146	0	0
MIG21R	8.00	62.96	19.84	437.87	unk	0	0
MIG21UM	8.00	64.66	19.88	463.92	146	0	0
MIG23B	7.33	75.08	18.19	480.38	unk	0	1
MIG23E	7.33	70.04	18.27	522.25	unk	0	1
MIG23F	6.00	81.13	14.62	344.34	unk	0	1
MIG23G	7.33	72.96	18.23	501.80	unk	0	1
MIG23UM	7.33	73.30	18.01	370.79	unk	0	1
MIG25	6.00	104.40	14.69	413.46	146	0	0
MIG25R	6.00	100.66	14.73	441.29	146	0	0
MIG25U	6.00	104.38	14.69	413.54	146	0	0
MIG27DJ	6.00	82.74	14.67	380.69	unk	0	1
MIG29	9.00	84.85	22.82	769.26	unk	1	0
MIG31	6.00	111.13	14.87	608.80	unk	0	0
MIRF1A	7.33	80.68	17.97	393.17	unk	1	0
MIRF1B	7.33	80.68	17.97	393.17	unk	1	0
MIRF1C	7.33	79.90	17.97	398.07	unk	1	0
MIRF1E	7.33	85.64	17.91	363.91	unk	1	0
MIRIIIC	7.33	47.44	17.98	299.23	unk	0	0
MIRIIIE	7.33	48.89	17.98	305.51	unk	0	0
MIRIIIEI	7.33	48.92	17.98	305.20	unk	0	0
MIR2000C	9.00	48.04	22.44	494.71	90	1	0
MIR2000R	7.33	45.56	18.28	527.85	90	1	0
MIR2000T	9.00	49.63	22.40	475.30	90	1	0
MIR3NG	7.33	57.27	17.97	358.40	unk	1	0
MIR4000	9.00	45.02	22.87	709.13	90	1	0
MIR5DD	7.33	59.39	17.82	233.63	unk	0	0
MIR5DR	7.33	58.35	17.84	239.61	unk	0	0
MIR5D1	7.33	49.90	17.96	297.22	unk	0	0
MIR5D1E	7.33	50.31	17.96	293.98	unk	0	0
MIR5D2	7.33	58.94	17.83	236.21	unk	0	0
OV10D	4.40	32.82	18.71	-122.09	unk	0	0
PRCA5	6.00	65.49	14.63	311.63	114	0	0
PRCFT6	6.00	53.57	14.90	476.03	126	0	0
PRCF6	6.00	55.53	14.87	536.35	126	0	0
PRCF7	8.00	61.80	19.77	398.72	unk	0	0
PRCF7E	8.00	61.65	19.77	444.33	unk	0	0
RF4C	7.00	69.40	17.37	536.99	unk	0	0
RF5E	7.33	71.10	18.00	400.31	124	1	0
SF260MW	4.40	21.59	28.35	-322.22	72	0	0
SF260TP	4.40	20.11	21.66	-326.29	68	0	0
SUPETEN	6.50	62.97	15.73	243.70	104	0	0
SU20	6.50	70.76	15.97	399.07	124	1	1
SU22	6.50	74.84	15.95	386.80	124	1	1
SU25	7.50	59.24	21.35	279.14	unk	0	0
SU27	9.00	97.90	22.90	821.23	unk	0	0
SU7BMKL	6.50	82.09	15.98	393.95	195	0	0
SU7U	6.50	81.95	15.98	394.76	195	0	0
TA4EH	7.33	65.02	17.69	179.45	unk	0	0
TA4KU	7.33	68.15	17.72	203.47	unk	0	0
TORADV	7.50	103.48	18.49	482.32	100	1	1
TORIDS	7.50	119.96	18.31	373.00	104	1	1
TU16AG	4.00	73.50	9.32	37.16	unk	0	0
TU22BD	4.00	101.76	9.38	131.64	unk	0	0

ACFT	AIRAD	GARAD	FRANGE	FUFRAC	CRANGE
ALPHAMS1	na	315	2160	.31	na
ALPHAMS2	na	315	2160	.32	unk
AMX	na	480	1600	.25	unk
A10A	na	300	2131	.33	unk
A37B	na	216	878	.36	399
A4H	na	375	3000	.35	1741
A4KU	na	291	1740	.35	unk
A4N	na	355	1788	.33	800
A7E	na	622	2431	.35	unk
A7P	na	622	2431	.34	unk
BAC167	na	255	1404	.26	630
CM170	na	251	755	.26	unk
CM170I	na	251	755	.26	unk
C101BB	na	205	2000	.36	unk
C101CC	na	280	2000	.36	unk
C101DD	na	280	2000	.36	unk
FA18L	575	450	2500	.33	unk
F104GCF	na	150	1566	.29	unk
F14AC	590	na	3409	.29	1735
F15A	600	450	2604	.29	unk
F15B	550	380	2604	.29	unk
F15C	600	450	3005	.32	unk
F15CFP	720	550	3450	.45	unk
F15D	550	400	3005	.32	unk
F15E	670	490	3005	.32	unk
F16A	550	440	2100	.31	unk
F16B	500	400	2100	.26	unk
F16C	500	440	2100	.28	unk
F16CSC	500	440	2100	.28	unk
F16D	460	410	2100	.27	unk
F16J79	375	255	1575	.28	unk
F20	410	385	1620	.31	unk
F20A	410	385	1620	.31	unk
F4CD	350	270	2000	.36	unk
F4EF	375	275	1610	.34	unk
F4MOD	685	500	1610	.40	unk
F5A	290	187	1205	.28	unk
F5B	290	187	1205	.27	unk
F5E	360	275	1345	.29	unk
F5F	300	225	1105	.30	unk
F86F	310	220	1250	.26	unk
G91Y	na	305	1890	.30	unk
HARMK80	400	250	2340	.28	unk
HAWK200	540	325	2200	.26	1950
HAWK50T	na	275	1675	.28	unk
HAWK60A	440	275	2200	.28	unk
HAWK60T	440	275	2200	.28	unk
HUNTER	490	290	1840	.19	unk
HUNTERT	525	300	1840	.19	unk
IL28	na	538	2431	.34	1176
JAGI04	na	451	1902	.33	unk
JAGI11	na	451	1902	.33	unk
JASTREB	na	170	820	.29	669
KFIRC2	470	415	2100	.26	unk
KFIRC7	540	420	2100	.26	unk
KFIRTC2	400	365	1900	.25	unk
LAVI	470	325	1050	.28	unk
LIGHTNG	432	260	1600	.30	unk
L29	na	175	480	.27	344
L39ZA	250	200	944	.21	540
MB326K	na	145	1151	.21	unk
MB326L	na	145	1151	.21	unk
MB339A	320	201	1140	.26	950
MB339C	na	330	1140	.33	950
MB339K	na	330	1140	.33	950
MIG15BIS	300	200	1006	.24	719

MIG15UTI	250	150	725	.25	513
MIG17F	310	220	1070	.24	444
MIG19C	371	210	1188	.23	600
MIG21C	400	na	971	.25	unk
MIG21F	372	217	1147	.26	unk
MIG21JKL	400	200	971	.28	unk
MIG21R	na	280	1147	.26	unk
MIG21UM	360	210	1147	.25	unk
MIG23B	470	385	1514	.36	unk
MIG23E	470	385	1514	.36	unk
MIG23F	na	350	1514	.33	unk
MIG23G	470	385	1514	.36	unk
MIG23UM	420	330	1314	.32	unk
MIG25	610	na	1392	.38	unk
MIG25R	na	487	1392	.38	unk
MIG25U	590	450	1392	.38	unk
MIG27DJ	na	460	1350	.34	unk
MIG29	360	325	1500	.26	unk
MIG31	810	na	1392	.36	unk
MIRF1A	670	406	1748	.31	unk
MIRF1B	640	376	1748	.31	unk
MIRF1C	670	446	1748	.31	unk
MIRF1E	700	450	2036	.29	unk
MIRIIIC	416	na	2162	.27	870
MIRIIIE	648	348	2162	.26	870
MIRIIIEI	648	348	2162	.26	870
MIR2000C	378	280	2100	.28	800
MIR2000R	na	465	2100	.26	800
MIR2000T	358	260	2100	.27	740
MIR3NG	700	650	2200	.26	unk
MIR4000	870	465	2100	.45	unk
MIR5DD	na	640	1950	.28	unk
MIR5DR	na	700	2158	.29	unk
MIR5D1	600	na	2158	.29	unk
MIR5D1E	600	na	2158	.29	unk
MIR5D2	na	700	2158	.29	unk
OV10D	na	198	1243	.20	270
PRCA5	na	348	1080	.31	unk
PRCFT6	370	200	1187	.21	750
PRCF6	370	249	1187	.23	750
PRCF7	400	200	971	.25	unk
PRCF7E	400	200	971	.25	unk
RF4C	na	306	2000	.34	unk
RF5E	na	285	1545	.30	unk
SF260MW	na	260	926	.17	unk
SF260TP	na	260	925	.20	512
SUPETEN	na	351	1782	.28	unk
SU20	na	340	1220	.27	unk
SU22	na	378	1480	.28	unk
SU25	na	300	1500	.37	unk
SU27	810	350	1500	.28	900
SU7BMKL	na	261	783	.21	436
SU7U	na	187	780	.21	436
TA4EH	na	250	2500	.35	unk
TA4KU	na	255	1500	.33	1500
TORADV	750	na	2100	.33	unk
TORIDS	na	751	2100	.31	unk
TU16AG	na	1565	3000	.41	2605
TU22BD	na	1670	3200	.50	unk

ACFT	MAXORD	STNS	NGUN	CAL	ROUNDS
ALPHAMS1	5510	5	0	0	0
ALPHAMS2	5510	5	1	30	125
AMX	8377	5	1	20	350
A10A	14341	10	1	30	1174
A37B	5680	6	1	8	200
A4H	8600	5	2	20	400
A4KU	8600	5	2	20	400
A4N	9470	7	2	30	300
A7E	15000	6	1	20	1032
A7P	14250	6	1	20	1032
BAC167	3000	4	2	8	200
CM170	330	2	2	8	360
CM170I	330	2	2	8	360
C101BB	4960	6	1	30	200
C101CC	4960	6	2	13	200
C101DD	4960	6	2	13	200
FA18L	17000	8	1	20	570
F104GCF	7500	7	1	20	725
F14AC	14500	8	1	20	675
F15A	15500	5	1	20	940
F15B	15500	5	1	20	940
F15C	15500	5	1	20	940
F15CFP	16000	7	1	20	940
F15D	15500	5	1	20	940
F15E	23500	9	1	20	940
F16A	15200	7	1	20	515
F16B	15200	7	1	20	515
F16C	15200	7	1	20	515
F16CSC	15200	7	1	20	515
F16D	15200	7	1	20	515
F16J79	11950	7	1	20	515
F20	8300	7	2	20	900
F20A	8300	7	2	20	900
F4CD	16000	6	0	0	0
F4EF	19080	6	1	20	639
F4MOD	23080	9	1	20	639
F5A	6200	5	2	20	280
F5B	6200	5	2	20	280
F5E	7000	5	2	20	280
F5F	7000	5	1	20	280
F86F	2000	2	6	13	200
G91Y	4000	4	2	30	200
HARMK80	8000	5	2	30	250
HAWK200	6800	5	2	30	300
HAWK50T	1540	3	1	30	120
HAWK60A	6800	5	1	30	120
HAWK60T	1540	5	1	30	120
HUNTER	7100	4	2	30	200
HUNTERT	7100	4	2	30	200
IL28	6614	6	4	23	650
JAGI04	10500	6	2	30	300
JAGI11	10500	6	2	30	300
JASTREB	2420	6	3	.5	405
KFIRC2	8500	7	2	30	280
KFIRC7	12250	7	2	30	280
KFIRTC2	8500	7	2	30	280
LAVI	6000	10	2	30	280
LIGHTNG	6000	6	2	30	240
L29	440	2	2	8	200
L39ZA	2425	4	1	23	150
MB326K	4000	6	2	30	200
MB326L	4000	6	0	30	200
MB339A	4000	6	0	0	0
MB339C	4270	6	2	30	280
MB339K	4270	6	2	30	280
MIG15BIS	2000	2	2	23	160

MIG15UTI	0	0	2	23	200
MIG17F	1650	2	3	23	200
MIG19C	2900	2	3	30	200
MIG21C	2000	2	1	23	200
MIG21F	4400	3	1	23	200
MIG21JKL	4400	3	1	23	200
MIG21R	2000	2	1	23	200
MIG21UM	4400	3	1	23	200
MIG23B	4400	4	1	23	200
MIG23E	4400	4	1	23	200
MIG23F	4400	4	1	23	200
MIG23G	4400	4	1	23	200
MIG23UM	4400	4	1	23	200
MIG25	8000	4	0	0	0
MIG25R	8000	4	0	0	0
MIG25U	8000	4	0	0	0
MIG27DJ	6615	5	1	23	500
MIG29	8800	6	1	23	200
MIG31	12000	6	1	30	360
MIRF1A	8820	5	2	30	270
MIRF1B	8820	5	2	30	270
MIRF1C	8820	5	2	30	270
MIRF1E	8820	5	2	30	270
MIRIIIC	3000	3	2	30	250
MIRIIIE	8818	5	2	30	250
MIRIIIEI	8818	7	2	30	250
MIR2000C	13890	7	2	30	250
MIR2000R	1250	4	2	30	200
MIR2000T	13890	7	2	30	250
MIR3NG	9260	7	2	30	250
MIR400C	17635	9	2	30	200
MIR5DD	8000	5	2	30	250
MIR5DR	8818	2	2	30	250
MIR5D1	400	2	2	30	250
MIR5D1E	400	2	2	30	250
MIR5D2	9260	5	2	30	250
OV10D	3600	5	2	8	1000
PRCA5	4410	5	2	23	500
PRCFT6	0	0	1	30	200
PRCF6	0	0	2	23	200
PRCF7	2000	2	1	23	200
PRCF7E	2000	2	1	23	200
RF4C	400	2	0	0	0
RF5E	400	2	1	20	280
SF260MW	661	4	2	8	0
SF260TP	661	4	0	0	0
SUPETEN	4630	6	2	30	250
SU20	8820	8	2	30	140
SU22	11023	8	2	30	140
SU25	8820	10	1	30	200
SU27	13225	6	1	23	200
SU7BMKL	5500	4	2	30	140
SU7U	5500	4	2	30	140
TA4EH	8200	5	2	20	400
TA4KU	8200	5	2	20	400
TORADV	18000	6	1	27	200
TORIDS	19840	9	2	27	200
TU16AG	19800	8	7	23	200
TU22BD	26450	10	1	23	200

B.2 Target Acquisition Systems

NAME	CODE	PWR	CONE	UPRNG	DWNRNG	DATAPTS
AGAVE	RAMU	100	140	10	0	2
AIDAII	RAGA	80	18	0	10	2
AIRPASSI	RAAI	900	90	80	0	2
ANTILOPE	RAMU	500	120	50	40	4
APG63	RAMU	1300	120	100	37	4
APG64	RAMU	1300	120	120	47	4
APG65	RAMU	500	120	45	34	4
APG66	RAMU	400	120	38	29	3
APG67	RAMU	330	160	47	38	4
APG68	RAMU	400	120	51	47	4
APG69	RAMU	80	90	20	14	4
APG70	RAMU	1300	120	120	50	4
APN153V	RAGA	80	90	0	10	2
APQ109	RAMU	150	90	20	0	3
APQ120	RAMU	200	90	25	0	3
APQ159	RAAI	80	90	10	0	3
AWG9	RAAI	1300	120	110	80	4
BLUEFOX	RAMU	200	120	30	15	4
CYRI	RAAI	100	120	14	0	3
CYRII	RAMU	200	120	30	0	3
CYRIV	RAAI	200	120	30	0	4
CYRIVM3	RAMU	200	120	30	15	4
CYRIV2	RAMU	200	120	30	15	4
ELM2001B	RAMU	200	90	30	0	2
ELM2021B	RAMU	200	90	35	25	4
ELTAFIAR	RAGA	200	90	0	30	2
FLANRAD	RAMU	1200	120	130	40	4
FOXFIRE	RAAI	600	120	50	0	4
FOXHUNT	RAMU	1200	120	97	70	4
FULRAD	RAMU	400	90	40	30	3
HIFIX	RAMU	80	40	4	0	2
HILARKI	RAMU	200	90	25	0	4
HILARKII	RAMU	300	90	35	15	4
HILARKX	RAAI	400	120	40	20	4
HOUNDRAD	RAAI	1200	120	100	50	4
IRSTSB	IRAI	80	40	15	10	2
IRSTSG	IRAI	100	60	20	15	2
JAYBIRD	RAAI	150	90	18	0	3
LASDES	LAGA	80	30	0	2	2
LASRNG	LAGA	80	20	0	2	2
RDA12	RAGA	200	90	0	20	0
RDI	RAAI	600	120	54	20	4
RDM	RAMU	600	120	60	20	4
SCANFIX	RAAI	80	60	4	0	2
SCANODD	RAAI	80	60	6	0	2
SHRTHRN	RAGA	200	90	0	30	2
SKYRNGR	RAAI	80	90	9	0	2
SPNSCNA	RAAI	100	60	11	0	2
SPNSCNB	RAAI	100	60	11	0	2
TI-ATA	RAMU	300	120	30	20	4
TI-ATG	RAMU	300	120	80	20	4
VISUAL	VIMU	40	30	10	3	1

NAME	TWS	ILLUM	MAP	DBS	ECCM
AGAVE	0	1	1	1	.7
AIDAII	0	0	0	0	.7
AIRPASSI	0	0	0	0	.9
ANTILOPE	1	0	1	1	1.1
APG63	1	1	0	1	1.0
APG64	1	1	0	1	1.1
APG65	1	1	1	1	1.0
APG66	0	0	1	1	1.0
APG67	1	0	1	1	1.1
APG68	1	1	1	1	1.1
APG69	1	1	0	1	1.0
APG70	1	1	1	1	1.1
APN153V	0	0	0	0	.8
APQ109	0	1	0	0	.7
APQ120	0	1	1	0	.8
APQ159	0	0	0	0	.8
AWG9	1	1	1	1	1.0
BLUEFOX	0	0	1	0	.9
CYRI	0	1	0	0	.7
CYRII	0	1	1	0	.8
CYRIV	0	0	0	0	.9
CYRIVM3	1	1	1	1	1.1
CYRIV2	0	1	0	1	1.0
ELM2001B	0	0	0	0	.9
ELM2021B	1	0	1	1	1.1
ELTAFIAR	0	0	0	0	.9
FLANRAD	1	1	0	1	1.0
FOXFIRE	0	1	1	0	.8
FOXHUNT	1	1	0	0	1.0
FULRAD	0	1	1	1	1.0
HIFIX	0	0	0	0	.7
HILARKI	0	1	0	0	.8
HILARKII	0	1	0	0	1.0
HILARKX	1	1	1	1	1.0
HOUNDRAD	1	1	1	1	1.1
IRSTSB	0	0	0	0	.8
IRSTSG	0	0	0	0	.8
JAYBIRD	0	1	0	0	.8
LASDES	0	1	0	0	1.0
LASRNG	0	0	0	0	1.0
RDA12	0	0	0	0	.8
RDI	1	1	1	1	1.1
RDM	1	1	1	1	1.1
SCANFIX	0	1	0	0	.7
SCANODD	0	0	0	0	.7
SHRTHRN	0	0	1	0	.8
SKYRNGR	0	0	0	0	.8
SPNSCNA	0	1	0	0	.8
SPNSCNB	0	1	0	0	.8
TI-ATA	1	1	0	0	1.1
TI-ATG	0	0	1	1	1.1
VISUAL	0	0	0	0	1.0

B.3 Air-to-Air Missiles

MSL	CODE	DIAM	LENGTH	MSLWGHT	WHWGHT
AA2B	AAMI	4.7	110.0	190.0	13.2
AA2C	AAMR	4.7	114.0	190.0	13.2
AA2D	AAMI	4.7	110.0	190.0	13.2
AA6A	AAMR	15.7	232.0	1565	88.0
AA6B	AAMI	15.7	248.0	1565	88.0
AA7A	AAMR	8.8	181.0	705.0	88.0
AA7B	AAMI	8.8	177.0	660.0	88.0
AA8B	AAMI	4.7	84.6	121.0	17.0
AA9A	AAMR	8.8	170.0	650.0	100.0
AIM120A	AAMR	7.0	145.7	326.0	50.0
AA10A	AAMR	7.0	145.7	326.0	50.0
AIM9D	AAMI	4.0	113.0	195.0	22.4
AIM9E	AAMI	4.0	118.1	164.0	10.0
AIM9G	AAMI	4.0	113.0	191.0	22.4
AIM9H	AAMI	4.0	113.0	186.0	22.4
AIM9J	AAMI	4.0	120.9	172.0	10.0
AIM9L	AAMI	4.0	112.2	188.0	25.0
AIM9M	AAMI	4.0	112.2	190.0	25.0
AIM9PN	AAMI	4.0	120.9	172.0	10.0
SKYFLASH	AAMR	9.0	145.0	425.0	66.0
AIM7C	AAMR	8.0	144.0	380.0	66.0
AIM7D	AAMR	8.0	144.0	440.0	66.0
AIM7E	AAMR	8.0	144.0	452.0	66.0
AIM7F	AAMR	8.0	144.0	503.0	88.0
AIM7M	AAMR	8.0	145.0	503.0	88.0
KUKRI	AAMI	5.0	115.9	161.5	10.0
ASPIDE	AAMR	8.0	145.5	485.0	72.8
FIRESTRK	AAMI	8.8	125.5	300.0	50.0
R550	AAMI	6.2	109.0	198.0	27.6
STINGER	AAMI	2.8	60.0	22.3	6.6
AIM54	AAMR	15.0	157.8	985.0	132.0
PIRANHA	AAMI	6.0	105.0	190.0	26.5
PYTHON3	AAMI	6.3	97.0	200.0	24.0
R530R	AAMR	10.4	129.3	423.3	60.0
R530I	AAMI	10.4	125.9	426.6	60.0
SUP530F	AAMR	10.4	139.4	551.0	66.0
RBS70	AAMI	4.2	52.0	33.0	2.2
REDTOP	AAMI	8.8	130.6	330.0	68.3
SHAFRIR	AAMI	6.3	97.0	205.0	24.3
R550MK2	AAMI	6.2	109.0	198.0	27.6
SUP530D	AAMR	10.4	139.4	500.0	66.0

MSL	GUIDTYP	GUIDSC	MODE	MSPD	LIMG	ECCM
AA2B	IR	.9	VR	2.5	25	1.1
AA2C	SARH	.8	VR	2.5	30	.9
AA2D	IR	.9	VR	2.5	30	.9
AA6A	SARH	1.0	BVR	2.2	16	.9
AA6B	IR	1.0	VR	2.2	16	.8
AA7A	SARH	1.0	BVR	3.0	15	.9
AA7B	IR	1.0	VR	3.0	15	.9
AA8B	IR	1.0	VR	3.0	30	.8
AA9A	SARH	1.0	BVR	4.0	15	.7
AIM120A	ARH	1.2	BVR	4.0	30	.7
AA10A	SARH	.8	BVR	4.0	30	.7
AIM9D	IR	.9	VR	2.5	25	1.0
AIM9E	IR	.9	VR	2.5	25	.9
AIM9G	IR	1.0	VR	2.5	25	.9
AIM9H	IR	1.0	VR	2.5	25	.9
AIM9J	IR	1.0	VR	2.5	30	.8
AIM9L	IR	1.0	VR	2.5	30	.8
AIM9M	IR	1.0	VR	2.5	30	.7
AIM9PN	IR	1.0	VR	2.5	30	.9
SKYFLASH	SARH	1.0	BVR	4.0	16	.8
AIM7C	SARH	.8	VR	3.5	16	1.0
AIM7D	SARH	.8	VR	3.5	16	1.0
AIM7E	SARH	.8	VR	3.7	20	.9
AIM7F	SARH	1.0	BVR	4.0	20	.8
AIM7M	SARH	1.0	BVR	4.0	20	.7
KUKRI	IR	1.0	VR	1.8	35	.9
ASPIDE	SARH	1.0	BVR	4.0	15	.8
FIRESTRK	IR	.9	VR	3.0	20	1.0
R550	IR	1.0	VR	3.0	25	1.0
STINGER	IR	1.0	VR	1.5	20	.9
AIM54	ARH	1.2	BVR	5.0	20	.8
PIRANHA	IR	1.0	VR	2.2	25	.9
PYTHON3	IR	1.0	VR	2.5	30	.8
R530R	SARH	.8	VR	2.7	25	.9
R530I	IR	1.0	VR	2.7	25	1.0
SUP530F	SARH	.8	VR	4.6	25	.8
RBS70	LASR	.7	VR	1.5	25	.9
REDTOP	IR	1.0	VR	3.2	20	1.0
SHAFRIR	IR	1.0	VR	2.5	25	.8
R550MK2	IR	1.0	VR	3.0	30	.7
SUP530D	SARH	1.0	BVR	4.6	25	.7

MSL	MAXHRNG	MINHRNG	EFFHRNG	MAXTRNG	MINTRNG	EFFTRNG
AA2B	.0	.0	.00	3.5	.5	3.00
AA2C	.0	.0	.00	8.0	.5	7.50
AA2D	.0	.0	.00	8.0	.5	7.50
AA6A	30.0	2.2	27.80	10.0	1.1	8.90
AA6B	.0	.0	.00	15.5	1.1	14.40
AA7A	25.0	2.0	23.00	10.0	.5	9.50
AA7B	20.0	1.1	18.90	8.1	.5	7.60
AA8B	.0	.0	.00	3.0	.0	2.93
AA9A	35.0	2.0	33.00	12.0	.5	11.50
AIM120A	27.0	2.0	25.00	10.8	.5	10.30
AA10A	25.0	2.0	23.00	8.8	.5	8.30
AIM9D	.0	.0	.00	9.6	.6	9.00
AIM9E	.0	.0	.00	2.3	.6	1.70
AIM9G	.0	.0	.00	9.6	.4	9.20
AIM9H	.0	.0	.00	9.6	.4	9.20
AIM9J	.0	.0	.00	7.8	.4	7.40
AIM9L	13.4	.8	12.60	9.6	.2	9.40
AIM9M	13.4	1.0	12.40	9.6	.4	9.20
AIM9PN	.0	.0	.00	9.6	.2	9.40
SKYFLASH	26.3	3.0	23.30	7.0	1.1	5.90
AIM7C	21.8	3.0	18.80	11.0	1.1	9.90
AIM7D	21.8	3.0	18.80	11.0	1.1	9.90
AIM7E	24.4	3.0	21.40	12.0	1.1	10.90
AIM7F	53.9	2.0	51.90	18.0	.5	17.50
AIM7M	53.9	2.0	51.90	18.0	.5	17.50
KUKRI	.0	.0	.00	2.2	.2	2.04
ASPIDE	26.2	2.0	24.20	12.0	.5	11.50
FIRESTRK	.0	.0	.00	4.3	.6	3.65
R550	.0	.0	.00	5.4	.2	5.23
STINGER	2.6	1.0	1.60	2.4	.4	2.00
AIM54	108	2.5	105.5	36.0	1.0	35.00
PIRANHA	.0	.0	.00	3.2	.5	2.70
PYTHON3	8.1	1.1	7.00	3.2	.3	2.93
R530R	7.0	3.0	4.00	2.8	.8	1.96
R530I	7.0	3.0	4.00	2.8	.8	1.96
SUP530F	18.9	3.0	15.90	7.6	.8	6.76
RBS70	2.7	1.1	1.60	1.1	.3	.85
REDTOP	6.5	2.5	4.00	2.6	.6	1.95
SHAFRIR	.0	.0	.00	2.7	.5	2.20
R550MK2	7.6	.7	6.90	5.4	.2	5.23
SUP530D	37.0	1.0	36.00	14.8	.3	14.53

B.4 Aerial Guns

GUN	CODE	CAL	MRNG	DISP	MVEL	RATE
ADENMK4	ACCI	30.0	1.000	5.0	2600	1400
ADENMK5	ACCI	30.0	1.100	4.5	3100	1700
CB.50	ACCI	7.6	.593	5.0	2750	550
DEFA552A	ACCI	30.0	.500	2.5	2400	1300
DEFA553	ACCI	30.0	.750	2.2	2400	1300
DEFA554	ACCI	30.0	1.000	2.0	2700	1800
FN7.62	ACCI	7.6	.593	5.0	2750	550
GAU12U	ACCI	25.0	1.100	6.0	3600	4200
GAU13A	ACCE	30.0	1.200	2.0	3400	2400
GAU2BA	ACCE	7.6	.806	6.5	2700	4000
GAU8A	ACCI	30.0	1.187	5.0	3500	4200
GPU5A	ACCE	30.0	1.000	2.0	3000	2400
GSH23	ACCI	23.0	.243	4.5	2350	3000
HGS55	ACCE	7.6	.560	5.0	2800	570
HIS404	ACCI	20.0	.863	2.5	2800	640
KCA30	ACCE	30.0	1.079	2.5	3380	1350
MAU27	ACCI	27.0	1.000	2.0	3380	2400
MKIIMOD5	ACCE	20.0	.513	2.0	3380	4200
M16	ACCE	7.6	.539	5.0	2700	2600
M197	ACCE	20.0	.500	2.2	3400	3000
M230	ACCE	30.0	1.100	5.0	2600	625
M28	ACCE	7.7	.806	6.5	2700	4000
M39	ACCI	20.0	.500	2.2	2800	3000
M5	ACCE	40.0	.806	5.0	790	230
M61A1	ACCI	20.0	.539	2.2	3380	4000
M621	ACCE	20.0	.809	2.0	3380	740
NR23	ACCI	23.0	.197	4.0	1200	850
NR23HS	ACCI	23.0	.197	4.0	1250	900
NR30	ACCI	30.0	.248	3.5	2550	850
NR30GAT	ACCI	30.0	.329	4.0	2700	5150
N37	ACCI	37.0	.197	4.0	1200	400
N37D	ACCI	37.0	.197	4.0	2250	400
UBK	ACCE	12.7	.809	4.5	2900	700
US12.7	ACCI	12.7	.800	5.0	2900	700
XM188E30	ACCE	30.0	1.150	5.0	2600	2000
XM27E1	ACCE	7.6	.592	5.0	2850	4000
XM8	ACCE	40.0	1.187	5.0	790	400

B.5 Air Weapon System Configuration

ACFT	PRODCC	CREW	ARC	NAVCAT	MMHFH
ALPHAMS1	FR	2	0	TAC	18
ALPHAMS2	FR	2	0	DOP	20
AMX	IT	1	0	INS	20
A10A	US	1	1	INS	18
A37B	US	2	0	TAC	16
A4H	US	1	1	INS	30
A4KU	US	1	0	DOP	29
A4N	US	1	1	INS	30
A7E	US	1	1	INS	53
A7P	US	1	0	DOP	45
BAC167	UK	2	0	TAC	20
CM170	FR	2	0	TAC	18
CM170I	IS	2	0	TAC	20
C101BB	SP	2	0	TAC	20
C101CC	SP	2	0	TAC	20
C101DD	SP	2	0	TAC	18
FA18L	US	1	1	INS	24
F104GCF	US	1	1	INS	45
F14AC	US	2	1	INS	60
F15A	US	1	1	INS	41
F15B	US	2	1	INS	41
F15C	US	1	1	INS	34
F15CFP	US	1	1	INS	34
F15D	US	1	1	INS	34
F15E	US	2	1	INS	34
F16A	US	1	1	INS	30
F16B	US	2	1	INS	30
F16C	US	1	1	INS	25
F16CSC	US	1	1	INS	23
F16D	US	2	1	INS	25
F16J79	US	1	1	INS	25
F20	US	1	1	INS	15
F20A	US	1	1	INS	17
F4CD	US	2	1	INS	38
F4EF	US	2	1	INS	38
F4MOD	US	2	1	INS	38
F5A	US	1	0	TAC	16
F5B	US	2	0	TAC	16
F5E	US	1	0	INS	20
F5F	US	2	0	INS	20
F86F	US	1	0	DR	40
G91Y	IT	1	0	TAC	20
HARMK80	UK	1	1	DOP	44
HAWK200	UK	1	0	INS	24
HAWK50T	UK	2	0	TAC	20
HAWK60A	UK	1	0	TAC	24
HAWK60T	UK	1	0	TAC	20
HUNTER	UK	1	0	DR	44
HUNTERT	UK	2	0	DR	40
IL28	UR	3	0	TAC	60
JAGI04	UK	1	1	INS	38
JAGI11	UK	1	1	INS	38
JASTREB	YU	1	0	TAC	18
KFIRC2	IS	1	0	INS	18
KFIRC7	IS	1	0	INS	18
KFIRTC2	IS	2	0	INS	15
LAVI	IS	1	0	INS	26
LIGHTNG	UK	1	0	DR	40
L29	CZ	2	0	DR	19
L39ZA	CZ	2	0	TAC	19
MB326K	IT	1	0	DR	20
MB326L	IT	2	0	DR	18
MB339A	IT	2	0	TAC	18
MB339C	IT	1	0	INS	22

MB339K	IT	1	0	TAC	20
MIG15BIS	UR	1	0	DR	18
MIG15UTI	UR	2	0	DR	16
MIG17F	UR	1	0	DR	17
MIG19C	UR	1	0	DR	17
MIG21C	UR	1	0	DR	18
MIG21F	UR	1	0	DR	18
MIG21JKL	UR	1	0	DOP	18
MIG21R	UR	1	0	DOP	22
MIG21UM	UR	2	0	DR	18
MIG23B	UR	1	0	DOP	38
MIG23E	UR	1	0	DOP	36
MIG23F	UR	1	0	DOP	40
MIG23G	UR	1	0	DOP	38
MIG23UM	UR	2	0	DOP	36
MIG25	UR	1	0	DOP	32
MIG25R	UR	1	0	DOP	32
MIG25U	UR	1	0	DOP	32
MIG27DJ	UR	1	0	DOP	42
MIG29	UR	1	0	INS	25
MIG31	UR	2	0	INS	50
MIRF1A	FR	1	0	INS	38
MIRF1B	FR	2	0	INS	38
MIRF1C	FR	1	0	INS	34
MIRF1E	FR	1	0	INS	34
MIRIIIC	FR	1	0	DOP	38
MIRIIIE	FR	1	0	DOP	38
MIRIIIEI	FR	1	0	INS	38
MIR2000C	FR	1	0	INS	28
MIR2000R	FR	1	0	INS	30
MIR2000T	FR	2	0	INS	28
MIR3NG	FR	1	0	DOP	33
MIR4000	FR	1	1	INS	30
MIR5DD	FR	2	0	DOP	36
MIR5DR	FR	1	0	DOP	40
MIR5D1	FR	1	0	DOP	38
MIR5D1E	FR	1	0	DOP	38
MIR5D2	FR	1	0	DOP	40
OV10D	US	2	0	TAC	16
PRCA5	CH	1	0	TAC	22
PRCFT6	CH	2	0	DR	16
PRCF6	CH	1	0	DR	16
PRCF7	CH	1	0	TAC	18
PRCF7E	EG	1	0	TAC	18
RF4C	US	2	1	INS	42
RF5E	US	1	0	INS	22
SF260MW	IT	3	0	DR	16
SF260TP	IT	3	0	DR	16
SUPETEN	FR	1	1	INS	33
SU20	UR	1	0	DOP	26
SU22	UR	1	0	DOP	26
SU25	UR	1	0	TAC	18
SU27	UR	1	0	INS	41
SU7BMKL	UR	1	0	DR	18
SU7U	UR	2	0	DR	16
TA4EH	US	2	1	DOP	29
TA4KU	US	2	0	DOP	29
TORADV	UK	2	1	INS	30
TORIDS	UK	2	1	INS	34
TU16AG	UR	6	1	DR	70
TU22BD	UR	3	0	DR	70

ACFT	TARAD	TAOTH	RWR	PECM	AECM
ALPHAMS1	0	0	0	0	0
ALPHAMS2	0	LASRNG	0	0	1
AMX	ELTAFIAR	LASRNG	1	1	0
A10A	0	LASRNG	1	1	1
A37B	0	0	0	1	0
A4H	APN153V	0	1	0	1
A4KU	APN153V	0	1	0	0
A4N	APN153V	0	1	0	1
A7E	APQ126	LASRNG	1	1	1
A7P	APQ126	0	1	1	0
BAC167	0	0	0	0	0
CM170	0	0	0	0	0
CM170I	0	0	0	0	0
C101BB	0	0	0	0	0
C101CC	0	0	0	0	0
C101DD	0	0	0	0	0
FA18L	APG65	LASRNG	1	1	1
F104GCF	0	0	0	0	0
F14AC	AWG9	0	1	1	1
F15A	APG63	0	1	1	1
F15B	APG63	0	1	1	1
F15C	APG64	0	1	1	1
F15CFP	APG64	0	1	1	1
F15D	APG64	0	1	1	1
F15E	APG70	LASDES	1	1	1
F16A	APG66	LASRNG	1	1	1
F16B	APG66	LASRNG	1	1	1
F16C	APG68	LASRNG	1	1	1
F16CSC	APG66	0	1	1	0
F16D	APG68	LASRNG	1	1	1
F16J79	APG66	0	1	1	0
F20	APG67	0	1	1	0
F20A	APG67	0	1	1	1
F4CD	APQ109	0	1	1	1
F4EF	APQ120	LASDES	1	1	1
F4MOD	APG65	LASDES	1	1	1
F5A	0	0	0	1	0
F5B	0	0	0	1	0
F5E	APQ159	0	1	1	1
F5F	APQ159	LASDES	1	1	1
F86F	0	0	0	0	0
G91Y	RDA12	0	0	0	0
HARMK80	0	LASDES	1	1	1
HAWK200	BLUEFOX	LASRNG	1	0	1
HAWK50T	0	0	0	0	0
HAWK60A	0	LASRNG	0	0	0
HAWK60T	0	0	0	0	0
HUNTER	0	0	0	0	0
HUNTERT	0	0	0	0	0
IL28	0	0	1	0	0
JAGI04	0	LASRNG	1	1	0
JAGI11	0	LASRNG	1	1	0
JASTREB	0	0	0	0	0
KFIRC2	ELM2001B	0	1	1	1
KFIRC7	ELM2021B	0	1	1	1
KFIRTC2	0	0	1	1	1
LAVI	ELM2021B	0	1	1	1
LIGHTNG	AIRPASSI	0	0	0	0
L29	0	0	0	0	0
L39ZA	0	0	0	0	0
MB326K	0	0	0	0	0
MB326L	0	0	0	0	0
MB339A	0	0	1	1	0
MB339C	0	LASRNG	1	1	0
MB339K	0	0	1	1	0
MIG15BIS	0	0	0	0	0

MIG15UTI	0	0	0	0	0
MIG17F	SCANODD	0	0	0	0
MIG19C	SCANFIX	0	1	0	0
MIG21C	SPNSCNA	0	1	0	0
MIG21F	SPNSCNB	0	1	0	0
MIG21JKL	JAYBIRD	0	1	0	0
MIG21R	SPNSCNB	0	1	0	0
MIG21UM	SPNSCNB	0	1	0	0
MIG23B	HILARKI	IRSTSB	1	0	1
MIG23E	JAYBIRD	0	1	0	0
MIG23F	0	LASRNG	1	0	0
MIG23G	HILARKII	IRSTSG	1	0	1
MIG23UM	JAYBIRD	0	1	0	0
MIG25	FOXFIRE	0	1	0	1
MIG25R	FOXFIRE	0	1	0	1
MIG25U	FOXFIRE	0	1	0	1
MIG27DJ	0	LASRNG	1	1	1
MIG29	FULRAD	LASRNG	1	1	1
MIG31	HOUNDRAD	0	1	1	1
MIRF1A	AIDAII	LASRNG	1	0	1
MIRF1B	AIDAII	0	1	0	1
MIRF1C	CYRIV2	LASRNG	1	0	1
MIRF1E	CYRIVM3	LASRNG	1	0	1
MIRIIIC	CYRII	0	1	0	0
MIRIIIE	CYRIV	0	1	0	0
MIRIIIEI	CYRIV	0	1	1	1
MIR2000C	RDM	LASDES	1	1	1
MIR2000R	RDM	0	1	1	1
MIR2000T	RDM	LASDES	1	1	1
MIR3NG	CYRIVM3	0	1	0	1
MIR4000	RDI	LASDES	1	1	1
MIR5DD	AIDAII	0	1	0	0
MIR5DR	AIDAII	0	1	0	0
MIR5D1	AGAVE	0	1	0	0
MIR5D1E	CYRIVM3	0	1	0	0
MIR5D2	AGAVE	0	1	0	0
OV10D	0	LASDES	1	1	0
PRCA5	0	0	1	0	0
PRCFT6	SCANFIX	0	0	0	0
PRCF6	SCANFIX	0	0	0	0
PRCF7	SPNSCNB	0	1	0	0
PRCF7E	SPNSCNB	0	1	0	0
RF4C	APQ109	0	1	1	0
RF5E	APQ159	0	1	1	1
SF260MW	0	0	0	0	0
SF260TP	0	0	0	0	0
SUPETEN	AGAVE	0	1	0	1
SU20	HIFIX	0	1	1	1
SU22	HIFIX	LASDES	1	1	1
SU25	0	LASRNG	1	1	0
SU27	FLANRAD	0	1	1	1
SU7BMKL	HIFIX	0	1	1	0
SU7U	0	0	1	1	0
TA4EH	APN153V	0	1	0	0
TA4KU	APN153V	0	1	0	0
TORADV	FOXHUNT	0	1	0	1
TORIDS	TI-ATG	LASDES	1	1	1
TU16AG	SHRTHRN	0	1	0	1
TU22BD	SHRTHRN	0	1	0	1

ACFT	NAAMR	AAMR	NAAMI	AAMI	GUN	PGMC	SA	HUD	CRP
ALPHAMS1	0	0	2	R550	0	1	1	0	0
ALPHAMS2	0	0	2	R550	DEFA553	1	1	1	0
AMX	0	0	2	AIM9PN	M61A1	1	1	1	1
A10A	0	0	0	0	GAU8A	1	1	1	0
A37B	0	0	0	0	GAU2BA	0	0	0	0
A4H	0	0	2	SHAFRIR	DEFA552A	1	1	1	1
A4KU	0	0	2	AIM9PN	DEFA553	1	1	1	0
A4N	0	0	2	AIM9L	DEFA554	1	1	1	1
A7E	0	0	2	AIM9L	M61A1	1	1	1	1
A7P	0	0	2	AIM9PN	M61A1	1	1	1	0
BAC167	0	0	0	0	FN7.62	0	0	0	0
CM170	0	0	0	0	HGS55	0	0	0	0
CM170I	0	0	0	0	HGS55	0	0	0	0
C101BB	0	0	0	0	DEFA553	0	1	0	0
C101CC	0	0	0	0	DEFA553	0	1	0	0
C101DD	0	0	0	0	DEFA553	1	1	1	1
FA18L	2	AIM7M	2	AIM9L	M61A1	1	1	1	1
F104GCF	0	0	2	AIM9E	M61A1	0	0	0	0
F14AC	2	AIM54	2	AIM9J	M61A1	0	1	1	0
F15A	6	AIM7F	2	AIM9L	M61A1	1	1	1	0
F15B	6	AIM7F	2	AIM9L	M61A1	1	1	1	0
F15C	6	AIM7F	2	AIM9L	M61A1	1	1	1	0
F15CFP	6	AIM7M	2	AIM9M	M61A1	1	1	1	0
F15D	6	AIM7F	2	AIM9L	M61A1	1	1	1	0
F15E	6	AIM120A	2	AIM9M	M61A1	1	1	1	1
F16A	0	0	4	AIM9L	M61A1	1	1	1	1
F16B	0	0	4	AIM9L	M61A1	1	1	1	1
F16C	2	AIM7F	2	AIM9L	M61A1	1	1	1	1
F16CSC	0	0	4	AIM9PN	M61A1	1	1	1	0
F16D	2	AIM7F	2	AIM9L	M61A1	1	1	1	1
F16J79	0	0	4	AIM9PN	M61A1	1	1	1	0
F20	0	0	4	AIM9PN	M39	1	1	1	0
F20A	2	AIM7F	2	AIM9L	M39	1	1	1	0
F4CD	2	AIM7E	2	AIM9D	0	1	1	0	0
F4EF	2	AIM7F	2	AIM9L	M61A1	1	1	0	1
F4MOD	2	AIM7M	2	AIM9M	M61A1	1	1	1	1
F5A	0	0	2	AIM9J	M39	0	1	0	0
F5B	0	0	2	AIM9J	M39	0	1	0	0
F5E	0	0	2	AIM9PN	M39	1	1	0	0
F5F	0	0	2	AIM9PN	M39	1	1	0	0
F86F	0	0	0	0	US12.7	0	0	0	0
G91Y	0	0	0	0	DEFA552A	1	1	1	0
HARMK80	0	0	4	AIM9L	ADENMK5	1	1	1	1
HAWK200	0	0	2	AIM9L	ADENMK4	1	1	1	1
HAWK50T	0	0	2	AIM9PN	ADENMK4	0	1	1	0
HAWK60A	0	0	4	AIM9PN	ADENMK4	0	1	1	0
HAWK60T	0	0	2	AIM9PN	ADENMK4	0	1	1	0
HUNTER	0	0	0	0	ADENMK4	0	0	0	0
HUNTERT	0	0	0	0	ADENMK4	0	0	0	0
IL28	0	0	0	0	NR23	0	0	0	0
JAGI04	0	0	2	AIM9PN	ADENMK5	1	1	1	0
JAGI11	0	0	2	AIM9PN	ADENMK5	1	1	1	0
JASTREB	0	0	0	0	CB.50	0	0	0	0
KFIRC2	0	0	4	SHAFRIR	DEFA553	1	1	1	1
KFIRC7	0	0	4	PYTHON3	DEFA554	1	1	1	1
KFIRTC2	0	0	2	SHAFRIR	DEFA553	1	1	1	1
LAVI	0	0	4	PYTHON3	DEFA554	1	1	1	1
LIGHTNG	0	0	2	REDTOP	ADENMK4	0	1	0	0
L29	0	0	0	0	0	0	0	0	0
L39ZA	0	0	2	AA2B	GSH23	0	0	0	0
MB326K	0	0	2	R550	DEFA552A	0	0	0	0
MB326L	0	0	2	R550	0	0	0	0	0
MB339A	0	0	2	AIM9PN	0	0	1	0	0
MB339C	0	0	2	AIM9PN	DEFA553	0	1	1	1
MB339K	0	0	2	AIM9PN	DEFA553	0	1	0	0
MIG15BIS	0	0	0	0	N37	0	0	0	0

MIG15UTI	0	0	0	0	N37	0	0	0	0
MIG17F	0	0	0	0	N37D	0	0	0	0
MIG19C	0	0	2	AA2B	NR30	0	0	0	0
MIG21C	2	AA2C	2	AA2B	NR23	0	0	0	0
MIG21F	2	AA2C	2	AA2B	NR23HS	0	0	0	0
MIG21JKL	2	AA2C	2	AA2D	GSH23	0	1	0	0
MIG21R	0	0	2	AA2D	GSH23	0	1	0	0
MIG21UM	2	AA2C	2	AA2B	NR23HS	0	0	0	0
MIG23B	2	AA7A	2	AA7B	GSH23	1	1	1	0
MIG23E	2	AA2C	2	AA2D	GSH23	1	1	0	0
MIG23F	0	0	2	AA2D	GSH23	1	1	0	0
MIG23G	2	AA7A	2	AA8B	GSH23	1	1	1	0
MIG23UM	2	AA2C	2	AA2D	GSH23	1	1	1	0
MIG25	2	AA6A	2	AA6B	0	0	0	0	0
MIG25R	0	0	2	AA6B	0	0	1	0	0
MIG25U	2	AA6A	2	AA6B	0	0	0	0	0
MIG27DJ	0	0	2	AA8B	NR30	1	1	1	0
MIG29	4	AA9A	2	AA8B	NR30GAT	1	1	1	1
MIG31	4	AA9A	2	AA8B	NR30GAT	0	1	1	0
MIRF1A	0	0	4	R530I	DEFA553	1	1	0	0
MIRF1B	0	0	4	R530I	DEFA553	1	1	0	0
MIRF1C	2	SUP530F	2	R550	DEFA553	1	1	0	0
MIRF1E	2	SUP530F	2	R550	DEFA553	1	1	0	0
MIRIIIC	2	R530R	2	R530I	DEFA552A	0	1	1	0
MIRIIIE	2	R530R	2	R550	DEFA552A	1	1	1	0
MIRIIIEI	2	R530R	2	SHAFRIR	DEFA552A	1	1	1	1
MIR2000C	2	SUP530D	2	R550MK2	DEFA554	1	1	1	1
MIR2000R	0	0	2	R550MK2	DEFA554	1	1	1	1
MIR2000T	2	SUP530D	2	R550MK2	DEFA554	1	1	1	0
MIR3NG	2	SUP530F	2	R550MK2	DEFA552A	1	1	2	0
MIR4000	2	SUP530D	2	R550MK2	DEFA554	1	1	1	1
MIR5DD	0	0	2	R550	DEFA552A	0	1	1	0
MIR5DR	0	0	2	R550	DEFA552A	0	1	1	0
MIR5D1	2	R530R	2	R550	DEFA552A	0	1	1	0
MIR5D1E	2	SUP530D	2	R550MK2	DEFA552A	0	1	1	0
MIR5D2	0	0	2	R550	DEFA552A	1	1	1	0
OV10D	0	0	0	0	M197	0	1	0	0
PRCA5	0	0	0	0	NR30	0	1	1	0
PRCFT6	0	0	0	0	GSH23	0	0	0	0
PRCF6	0	0	2	AA2B	GSH23	0	0	0	0
PRCF7	2	AA2C	2	AA2B	GSH23	0	0	0	0
PRCF7E	2	AA2C	2	AIM9PN	GSH23	0	0	0	0
RF4C	0	0	0	0	0	1	1	0	0
RF5E	0	0	0	0	M39	1	1	0	0
SF260MW	0	0	0	0	0	0	0	0	0
SF260TP	0	0	0	0	0	0	0	0	0
SUPETEN	0	0	2	R550	DEFA553	1	1	1	0
SU20	0	0	2	AA2D	NR30	0	1	0	1
SU22	0	0	2	AA2D	NR30	1	1	0	1
SU25	0	0	0	0	NR30GAT	1	1	1	0
SU27	6	AA10A	0	0	NR30GAT	1	1	1	1
SU7BMKL	0	0	2	AA2B	NR30	0	0	0	0
SU7U	0	0	0	0	NR30	0	0	0	0
TA4EH	0	0	2	SHAFRIR	DEFA552A	0	1	1	1
TA4KU	0	0	2	AIM9E	DEFA552A	1	1	1	0
TORADV	4	SKYFLASH	4	AIM9L	MAU27	0	0	1	0
TORIDS	0	0	2	AIM9L	ADENMK5	1	1	1	1
TU16AG	0	0	0	0	NR23	1	0	0	0
TU22BD	0	0	0	0	NR23	1	0	0	0

Appendix C
AIRCREW SURVEY AND RELATIVE UTILITY VARIABLES

C.1 Aircrew Survey

AIRFRAME COMPONENT

1. What is the relative utility of the following airframe performance factors in achieving combat success in the roles indicated?

Mission	Top Useful Airspeed +	Maneuver-ability +	Combat Endurance = 100%
Air Defense			
Fighter			
Interdiction			
Close Air Spt			

PAYLOAD COMPONENT

2. What is the relative utility of each of the listed weapons types in achieving success in air defense and fighter missions respectively?

Mission	Infrared AAM +	Radar Guided AAM +	GUN = 100%
Air Defense			
Fighter			

3. What is the relative utility of each of the listed weapons types in achieving success in interdiction and CAS missions respectively?

Mission	Freefall Munitions +	Guided Munitions +	GUN = 100%
Interdiction			
Close Air Spt.			

TARGET ACQUISITION COMPONENT

4. What is the relative utility of each of the listed target acquisition methods in achieving success in the mission areas listed? Assume that no more than 10% of the operations will be conducted at night, and that weather will not play a limiting role. Judge the situation as if all three types of target acquisition were available.

Mission	Visual +	Radar +	Other (IRSTS, LASER) = 100%
Air Defense			
Fighter			
Interdiction			
Close Air Spt			

VULNERABILITY TO ENGAGEMENT

5. What is the utility of each of the following factors in reducing an aircraft's susceptibility to engagement during each of the mission types? Consider 'size' as a reciprocal measure (i.e., the smaller the better).

Mission	Top Useful Airspeed +	Maneuver- ability +	ECM +	Size/ Signature = 100%
Air Defense				
Fighter				
Interdiction				
Close Air Spt				

AIR WEAPON SYSTEM

6. What is the relative utility of each of the listed components in achieving mission success in each mission area?

Mission	Airframe +	Target Acquisition +	Payload = 100%
Air Defense			
Fighter			
Interdiction			
Close Air Spt			

EMPLOYMENT FACTORS

7. What is the relative utility of each of the following factors in assuring the success of the missions listed?

Mission	Air Weapon System +	Operator Proficiency +	C3I Support = 100%
Air Defense			
Fighter			
Interdiction			
Close Air Spt			

RESPONDANT INFORMATION

8. Please provide information concerning the following:

a. Current Aircraft: ____________

b. Aircrew Rating: ____________

c. Hours in Current Aircraft: ____________

d. Total Fighter Hours: ____________

e. Total Combat Hours: ____________

C.2 Survey Derived Relative Utility Values

AIRFRAME COMPONENT

Mission	Top Useful Airspeed	Maneuver-ability	Combat Endurance
Air Defense	.42	.29	.29
Fighter	.30	.43	.27
Interdiction	.38	.26	.36
Close Air Spt	.21	.38	.41

PAYLOAD COMPONENT

Air-to Air Missions

Mission	Infrared AAM	Radar Guided AAM	GUN
Air Defense	.31	.56	.13
Fighter	.39	.39	.22

Air-to-Ground Missions

Mission	Freefall Munitions	Guided Munitions	GUN
Interdiction	.38	.48	.14
Close Air Spt.	.28	.31	.41

TARGET ACQUISITION COMPONENT

Mission	Visual	Radar	Other (IRSTS, LASER)
Air Defense	.20	.61	.17
Fighter	.32	.51	.17
Interdiction	.39	.35	.26
Close Air Spt	.57	.13	.30

VULNERABILITY TO ENGAGEMENT

Mission	Top Useful Airspeed	Maneuverability	ECM	Size/ Signature
Air Defense	.37	.26	.18	.19
Fighter	.28	.32	.18	.22
Interdiction	.35	.23	.23	.19
Close Air Spt	.19	.39	.20	.22

AIR WEAPON SYSTEM

Mission	Airframe	Target Acquisition	Payload
Air Defense	.28	.41	.31
Fighter	.33	.37	.30
Interdiction	.27	.37	.36
Close Air Spt	.27	.34	.39

EMPLOYMENT FACTORS

Mission	Air Weapon System	Operator Proficiency	C3I Support
Air Defense	.34	.34	.32
Fighter	.36	.41	.23
Interdiction	.39	.41	.20
Close Air Spt	.36	.43	.21

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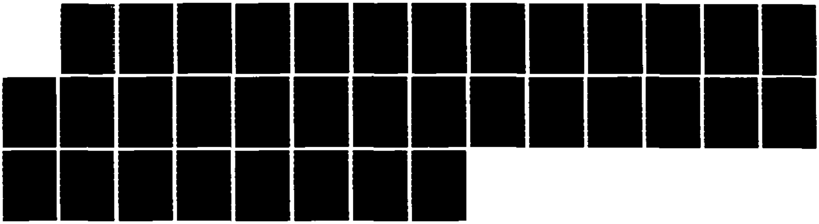

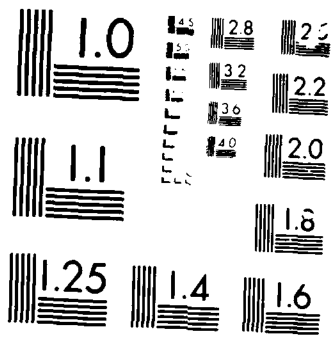
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Appendix D

MIDDLE EAST AIR ORDERS OF BATTLE 1984-1990

ALGERIA

ACFT	EMCODE	1984	1985	1986	1987	1988	1989	1990
CM170	CIN	24	20	20	20	20	20	20
MIG15BIS	OCG	4	0	0	0	0	0	0
MIG15UTI	TNG	20	20	20	20	20	20	20
MIG17F	FGA	60	60	50	40	30	20	0
MIG17F	TNG	10	10	10	10	5	5	0
MIG21F	FIN	95	95	95	95	84	72	60
MIG21UM	OCA	10	10	10	10	10	10	10
MIG23F	FGA	40	60	60	60	60	60	60
MIG23UM	OCG	2	2	2	2	2	2	2
MIG25	FIN	18	15	15	15	15	0	0
MIG25R	REC	4	6	6	6	6	6	6
MIG25U	OCA	3	3	3	3	3	3	3
MIG29	FIN	0	0	0	0	12	24	36
MIG31	FIN	0	0	0	0	0	18	18
SU20	FGA	18	18	18	18	18	18	18
SU25	FGA	0	0	0	12	12	12	12
SU7BMKL	FGA	20	12	12	0	0	0	0

OAR= .6
MXRAT= 3.75

BAHRAIN

ACFT	EMCODE	1984	1985	1986	1987	1988	1989	1990
F5E	FMR	4	6	8	8	8	8	8
F5F	FMR	2	2	4	4	4	4	4

OAR= .5
MXRAT= 2.5

EGYPT

ACFT	EMCODE	1984	1985	1986	1987	1988	1989	1990
ALPHAMS1	TNG	0	8	20	20	20	20	20
ALPHAMS2	FGA	15	19	26	26	26	26	26
F16A	FIN	34	32	32	32	32	32	32
F16B	OCA	6	6	6	6	6	6	6
F16C	FIN	0	0	0	17	34	34	34
F16D	OCA	0	0	6	6	6	6	6
F4EF	FMR	33	33	33	16	0	0	0
IL28	REC	10	5	0	0	0	0	0
L29	TNG	59	50	30	20	10	0	0
MIG15UTI	TNG	0	0	0	0	0	0	0
MIG17F	FGA	50	24	12	12	0	0	0
MIG19C	FIN	23	16	16	8	0	0	0
MIG21F	FIN	60	48	32	16	0	0	0
MIG21JKL	FIN	62	62	54	36	18	18	18
MIG21R	REC	15	15	15	15	15	15	15
MIG21UM	OCA	21	21	21	21	21	6	6
MIG23E	FIN	0	0	0	0	0	0	0
MIR2000C	FGA	0	0	0	0	17	34	34
MIR2000T	OCA	0	0	0	6	6	6	6
MIR5DD	OCA	6	6	6	6	3	0	0
MIR5DR	REC	6	6	6	6	6	6	6
MIR5D1E	FIN	0	0	6	12	16	16	16
MIR5D2	FGA	46	50	54	54	47	24	24
PRCFT6	OCA	4	4	4	12	18	22	22
PRCF6	FGA	32	70	78	78	78	78	78
PRCF6	FIN	12	12	12	12	12	12	12
PRCF7	FIN	10	20	36	54	72	72	72
SU20	FGA	0	0	0	0	0	0	0
SU7BMKL	FGA	20	20	0	0	0	0	0
TU16AG	BMR	7	7	7	7	7	7	7

OAR= .6
MXRAT= 4.68

ETHIOPIA

ACFT	EMCODE	1984	1985	1986	1987	1988	1989	1990
F5B	OCG	2	2	0	0	0	0	0
F5E	FGA	6	6	0	0	0	0	0
L39ZA	TNG	10	10	10	10	10	10	10
MIG17F	FGA	10	10	10	10	0	0	0
MIG21F	FGA	36	36	36	36	36	24	12
MIG21JKL	FGA	54	54	54	54	54	54	54
MIG21UM	OCG	10	10	10	10	10	10	10
MIG23F	FGA	20	35	38	38	38	38	38
SF260TP	TNG	4	4	8	10	10	10	10
SU25	FGA	0	0	0	0	12	24	36

OAR= .4
MXRAT= 2.4

IRAN

ACFT	EMCODE	1984	1985	1986	1987	1988	1989	1990
F14AC	FIN	25	20	15	10	6	6	6
F4CD	FMR	5	3	0	0	0	0	0
F4EF	FMR	30	20	20	15	10	10	10
F5E	FGA	40	32	24	16	16	16	16
F5F	FGA	10	7	5	3	3	3	3
PRCF6	FGA	0	12	12	12	12	12	12
RF4C	REC	3	3	3	3	3	3	3
RF5A	REC	10	5	0	0	0	0	0

OAR= .6
MXRAT= 22.8

IRAQ

ACFT	EMCODE	1984	1985	1986	1987	1988	1989	1990
HUNTER	TNG	12	12	12	12	6	0	0
HUNTERT	TNG	5	5	5	0	0	0	0
IL28	REC	0	0	0	0	0	0	0
L29	TNG	12	12	6	0	0	0	0
L39ZA	TNG	24	24	24	24	24	24	24
MIG15UTI	TNG	30	30	30	20	10	0	0
MIG17F	FIN	30	0	0	0	0	0	0
MIG19C	FIN	40	40	20	0	0	0	0
MIG21F	FIN	60	60	36	24	0	0	0
MIG21JKL	FIN	120	140	120	108	72	60	48
MIG21UM	OCA	6	6	6	6	6	6	6
MIG23E	FIN	48	48	60	72	84	84	84
MIG23F	FGA	16	18	36	36	36	36	36
MIG23UM	OCA	6	6	6	6	6	6	6
MIG25	FIN	10	17	17	17	17	17	17
MIG25R	REC	8	8	8	8	8	8	8
MIG27DJ	FGA	6	18	36	54	54	54	54
MIG29	FIN	0	0	0	0	12	24	36
MIRF1B	OCA	4	6	8	8	8	8	8
MIRF1C	FGA	0	8	20	20	20	20	20
MIRF1E	FIN	6	8	12	24	24	24	24
PRCF7	FIN	0	25	50	75	100	100	100
SUPETEN	FGA	5	5	5	0	0	0	0
SU20	FGA	45	50	60	70	80	80	80
SU25	FGA	0	0	0	12	24	24	24
SU7BMKL	FGA	40	40	36	18	0	0	0
TU16AG	BMR	8	6	6	6	6	6	6
TU22BD	BMR	7	7	7	7	7	7	7

OAR= .6
MXRAT= 6.68

ISRAEL

ACFT	EMCODE	1984	1985	1986	1987	1988	1989	1990
A4H	FGA	80	80	60	36	18	0	0
A4N	FGA	50	50	50	50	50	50	50
CM170I	TNG	85	85	85	85	85	85	85
F15A	FMR	18	18	18	18	18	18	18
F15B	OCM	2	2	2	2	2	2	2
F15C	FMR	20	20	32	32	32	32	32
F16A	FMR	62	62	62	62	62	62	62
F16B	OCM	8	8	8	8	8	8	0
F16C	FMR	0	0	0	36	54	67	67
F16D	OCM	0	0	8	8	8	8	8
F4EF	FMR	131	131	131	115	100	84	68
KFIRC2	FMR	120	120	120	120	120	120	120
KFIRC7	FMR	0	18	36	54	72	72	72
KFIRTC2	TNG	20	30	50	60	60	60	60
MIRIIIEI	FIN	0	0	0	0	0	0	0
RF4C	REC	13	13	13	13	13	13	13
TA4EH	TNG	73	73	73	73	73	73	73

OAR= .9
MXRAT= 7.75

JORDAN

ACFT	EMCODE	1984	1985	1986	1987	1988	1989	1990
C101DD	CIN	0	0	0	6	12	14	14
F5A	OCG	17	15	15	15	7	7	7
F5B	OCG	5	5	5	5	5	7	7
F5E	FGA	57	56	56	56	56	56	56
F5F	FGA	12	12	12	12	12	12	12
HUNTERT	TNG	3	0	0	0	0	0	0
MIRF1B	OCA	2	2	2	2	2	2	2
MIRF1C	FIN	15	19	19	19	19	19	19
MIRF1E	FIN	17	17	17	17	17	17	17

OAR= .8
MXRAT= 5.71

KUWAIT

ACFT	EMCODE	1984	1985	1986	1987	1988	1989	1990
A4KU	FGA	30	28	28	28	28	28	28
BAC167	TNG	9	9	9	9	9	9	9
HAWK60A	CIN	0	12	12	12	12	12	12
HUNTER	FGA	6	0	0	0	0	0	0
HUNTERT	OCA	3	0	0	0	0	0	0
LIGHTNG	FIN	0	0	0	0	0	0	0
MIRF1B	OCA	2	2	2	2	2	2	2
MIRF1C	FIN	17	32	41	41	41	41	41
TA4KU	OCG	6	6	6	6	6	6	6

OAR= .6
MXRAT= 2.25

LEBANON

ACFT	EMCODE	1984	1985	1986	1987	1988	1989	1990
HUNTER	FGA	3	3	0	0	0	0	0
HUNTERT	OCG	2	0	0	0	0	0	0
MIRIIIB	OCM	0	0	0	0	0	0	0
MIRIIIE	FMR	0	0	0	0	0	0	0

OAR=NA
MXRAT=NA

LIBYA

ACFT	EMCODE	1984	1985	1986	1987	1988	1989	1990
JASTREB	CIN	30	30	30	30	30	30	30
L39ZA	TNG	30	30	30	30	30	30	30
MIG21F	FIN	30	30	15	0	0	0	0
MIG23E	FIN	100	124	143	143	124	112	100
MIG23F	FGA	18	36	36	36	36	36	36
MIG23UM	OCA	14	14	14	14	14	14	14
MIG25	FIN	50	55	60	60	60	48	36
MIG25R	REC	7	7	7	7	7	7	7
MIG25U	OCA	5	5	5	5	5	5	5
MIG29	FIN	0	0	0	0	12	24	24
MIG31	FIN	0	0	0	0	0	12	24
MIRF1A	FGA	14	14	14	14	0	0	0
MIRF1B	OCA	6	6	6	6	6	6	6
MIRF1E	FIN	26	26	40	54	66	66	66
MIR5DD	OCG	13	13	13	13	13	13	13
MIR5DR	REC	7	7	7	7	7	7	7
MIR5D2	FGA	45	43	43	43	43	43	43
SF260MW	TNG	100	120	140	160	170	170	170
SU22	FGA	100	100	100	100	100	100	100
SU25	FGA	0	0	0	0	12	12	12
TU22BD	BMR	9	9	9	9	9	9	9

OAR= .3
MXRAT= 1.27

MOROCCO

ACFT	EMCODE	1984	1985	1986	1987	1988	1989	1990
ALPHAMS1	TNG	24	24	24	24	24	24	24
CM170	CIN	22	22	22	22	22	22	22
F5A	FGA	5	5	5	5	5	5	5
F5B	OCG	3	3	3	3	3	3	3
F5E	FGA	14	14	14	14	14	14	14
F5F	FGA	4	4	4	4	4	4	4
MIRF1C	FGA	18	18	18	18	18	18	18
MIRF1E	FGA	22	21	21	21	21	21	21
OV10D	CIN	6	6	6	6	6	6	6
RF5A	REC	12	12	12	12	12	12	12
SF260MW	TNG	28	28	28	28	28	28	28

OAR= .6
MXRAT= 8.28

OMAN

ACFT	EMCODE	1984	1985	1986	1987	1988	1989	1990
BAC167	CIN	12	12	12	12	12	12	12
HUNTER	FGA	12	12	12	6	6	6	6
HUNTERT	OCG	4	4	2	0	0	0	0
JAGI11	FGA	24	24	24	24	24	24	24
TORADV	FIN	0	0	0	4	8	8	8

OAR= .7
MXRAT= 5.73

QATAR

ACFT	EMCODE	1984	1985	1986	1987	1988	1989	1990
ALPHAMS2	FGA	6	8	8	8	8	8	8
HUNTER	FGA	3	2	2	0	0	0	0
HUNTERT	OCG	1	1	0	0	0	0	0
MIRF1B	OCG	0	0	2	2	2	2	2
MIRF1C	FGA	5	10	12	12	12	12	12

OAR= .6
MXRAT= 1.43

SAUDI ARABIA

ACFT	EMCODE	1984	1985	1986	1987	1988	1989	1990
BAC167	TNG	40	40	40	20	0	0	0
F15C	FIN	46	54	54	54	54	54	54
F15D	OCA	15	16	17	17	17	17	17
F5B	OCG	16	16	16	16	16	16	16
F5E	FGA	65	65	70	70	54	36	36
F5F	FGA	24	24	25	25	25	25	25
HAWK60T	TNG	0	0	0	15	30	[illegible]	30
LIGHTNG	FIN	17	17	16	0	0	0	0
RF5E	REC	0	0	10	10	10	10	10
TORADV	FIN	0	0	0	0	12	24	24
TORIDS	FGA	0	0	0	20	36	48	48

OAR= .7
MXRAT= 6.03

SOMALIA

ACFT	EMCODE	1984	1985	1986	1987	1988	1989	1990
HUNTER	FGA	10	10	10	10	10	10	10
HUNTERT	OCG	2	2	2	2	2	2	2
MIG15UTI	TNG	2	2	2	2	2	2	2
MIG17F	FGA	9	9	9	9	9	9	9
MIG21F	FMR	7	7	7	7	7	7	7
PRCF6	FMR	30	30	30	30	30	30	30
SF260MW	TNG	4	4	4	4	4	4	4
SF260MW	CIN	6	6	6	6	6	6	6

OAR= .4
MXRAT= 2.86

SUDAN

ACFT	EMCODE	1984	1985	1986	1987	1988	1989	1990
BAC167	CIN	3	3	7	10	10	10	10
F5E	FMR	2	2	6	10	10	10	10
F5F	FMR	2	2	2	2	2	2	2
MIG17F	FGA	10	10	10	6	3	0	0
MIG21F	FMR	8	8	8	8	8	8	8
MIG21UM	OCM	2	2	2	2	2	2	2
PRCFT6	OCA	2	2	2	2	2	2	2
PRCF6	FGA	6	6	9	12	12	12	12

OAR= .4
MXRAT= 8.57

SYRIA

ACFT	EMCODE	1984	1985	1986	1987	1988	1989	1990
IL28	BMR	0	0	0	0	0	0	0
L29	TNG	60	60	60	60	60	60	60
L39ZA	TNG	40	40	40	40	40	40	40
MIG15UTI	TNG	10	10	10	10	10	10	10
MIG17F	FGA	85	85	67	49	36	18	0
MIG21F	FIN	92	92	92	84	72	36	0
MIG21JKL	FIN	100	108	108	96	84	72	36
MIG21UM	OCA	20	20	20	20	20	20	20
MIG23B	FIN	24	24	24	24	24	24	24
MIG23E	FIN	24	24	24	36	48	60	72
MIG23F	FGA	50	50	60	70	70	70	70
MIG23G	FIN	0	36	36	36	36	36	36
MIG23UM	OCG	10	10	10	10	10	10	10
MIG25	FIN	25	25	30	38	38	38	38
MIG25R	REC	3	6	10	12	12	12	12
MIG29	FIN	0	0	0	12	24	36	72
SU22	FGA	40	42	42	42	42	42	42
SU25	FGA	0	0	0	12	24	36	36
SU27	FIN	0	0	0	0	0	0	24
SU7BMKL	FGA	36	36	24	12	0	0	0
SU7U	OCG	2	2	2	0	0	0	0

OAR= .7
MXRAT= 10.45

TUNISIA

ACFT	EMCODE	1984	1985	1986	1987	1988	1989	1990
F5E	FGA	0	8	8	8	8	8	8
F5F	OCG	0	4	6	6	6	6	6
MB326K	CIN	5	5	5	5	5	5	5
MB326K	TNG	7	7	7	7	7	7	7
MB326L	CIN	3	3	3	3	3	3	3
SF260MW	TNG	17	17	17	17	17	17	17

OAR= 5.68
MXRAT= .6

UNITED ARAB EMIRATES

ACFT	EMCODE	1984	1985	1986	1987	1988	1989	1990
ALPHAMS2	FGA	3	3	6	6	6	6	6
HAWK50T	TNG	3	3	3	3	3	3	3
HAWK60A	FGA	0	0	0	8	16	16	16
HAWK60T	OCG	0	0	8	8	8	8	8
HUNTER	FGA	0	0	0	0	0	0	0
HUNTERT	OCA	0	0	0	0	0	0	0
MB326K	CIN	5	5	5	5	5	5	5
MB326L	CIN	5	5	5	5	5	5	5
MB339A	TNG	2	2	4	4	4	4	4
MIRIIIE	FIN	0	0	0	0	0	0	0
MIR2000C	FIN	0	0	0	12	24	32	32
MIR2000R	REC	0	0	0	3	3	3	3
MIR2000T	OCA	0	0	3	3	3	3	3
MIR5DD	OCA	2	2	2	0	0	0	0
MIR5DR	REC	3	3	3	0	0	0	0
MIR5D1	FIN	25	24	24	12	0	0	0
SF260TP	TNG	6	6	6	6	6	6	6

OAR= .6
MXRAT= 2.83

NORTH YEMEN

ACFT	EMCODE	1984	1985	1986	1987	1988	1989	1990
F5B	TNG	4	4	4	4	4	4	4
F5E	FMR	10	8	8	8	8	8	8
IL28	BMR	0	0	0	0	0	0	0
MIG15UTI	TNG	4	4	4	4	4	4	4
MIG17F	FMR	10	10	10	10	10	10	10
MIG21F	FMR	40	40	40	40	40	40	40
SU22	FGA	15	15	15	15	15	15	15

OAR= .4
MXRAT= 1.23

SOUTH YEMEN

ACFT	EMCODE	1984	1985	1986	1987	1988	1989	1990
MIG15UTI	TNG	3	3	3	3	3	3	3
MIG17F	FIN	30	30	30	30	18	0	0
MIG21F	FIN	36	36	36	24	12	0	0
MIG21JKL	FGA	12	12	12	12	0	0	0
MIG21UM	OCA	1	1	1	1	1	1	1
MIG23E	FIN	0	0	0	12	24	36	36
MIG29	FIN	0	0	0	0	12	24	36
SU22	FGA	25	25	25	25	25	25	25
SU25	FGA	0	0	0	0	12	12	12

OAR= .5
MXRAT=2.34

Appendix E
AIR WEAPON SUBSYSTEM FACTOR SCORES

E.1 Airframes

Glossary

NFSS = Speed/Energy Factor Score
NFSM = Maneuverability Factor Score
NFSRA = Air-to-Air Range/Endurance Factor Score
NFSRG = Air-to-Ground Range/Endurance Factor Score
NFSO = Air-to-Ground Ordnance Factor Score
NRND = Indexed Gun Ordnance Capacity
NFSV = Size/Signature Factor Score

ACFT	ROLE	NFSS	NFSM	NFSRA	NFSRG	NFSO	NRND	NFSV
ALPHAMS1	FTTC	.601	1.041	.000	1.115	.834	.000	.689
ALPHAMS2	FTAT	.601	1.034	.000	1.115	.834	.382	.694
AMX	FTAT	.783	.927	.000	1.087	.959	1.069	.813
A10A	FTAT	.356	1.023	.000	1.088	1.813	3.587	1.546
A37B	FTAT	.413	.890	.000	.546	.960	.611	.761
A4H	FTAT	.604	.902	.000	1.482	.969	1.222	.763
A4KU	FTAT	.595	.902	.000	.937	.969	1.222	.763
A4N	FTAT	.636	.934	.000	1.022	1.244	.917	.773
A7E	FTAT	.742	.821	.000	1.537	1.367	3.153	1.151
A7P	FTAT	.637	.782	.000	1.537	1.335	3.153	1.153
BAC167	FTAT	.375	.771	.000	.778	.605	.611	.759
CM170	FTTC	.311	.896	.000	.539	.252	1.100	.776
CM170I	FTTC	.311	.896	.000	.539	.252	1.100	.776
C101BB	FTAT	.353	.953	.000	.941	.928	.611	.784
C101CC	FTAT	.377	.986	.000	1.020	.928	.611	.784
C101DD	FTTA	.377	.986	.000	1.020	.928	.611	.784
FA18L	FTMR	1.466	1.252	1.303	1.381	1.692	1.741	1.114
F104GCF	FTAT	1.373	1.031	.000	.725	1.158	2.215	.664
F14AC	FTIN	1.257	1.054	1.563	.000	.000	2.062	1.469
F15A	FTMR	1.506	1.236	1.358	1.418	1.271	2.872	1.451
F15B	FTTM	1.506	1.225	1.303	1.344	1.271	2.872	1.459
F15C	FTMR	1.506	1.380	1.466	1.563	1.271	2.872	1.460
F15CFP	FTMR	1.261	1.322	1.717	1.830	1.530	2.872	1.504
F15D	FTTM	1.506	1.370	1.411	1.511	1.271	2.872	1.467
F15E	FTMR	1.468	1.480	1.542	1.606	2.095	2.872	1.450
F16A	FTMR	1.462	1.386	1.168	1.225	1.495	1.573	.870
F16B	FTTM	1.462	1.384	1.113	1.183	1.495	1.573	.871
F16C	FTMR	1.462	1.312	1.113	1.225	1.495	1.573	.900
F16CSC	FTMR	1.462	1.326	1.113	1.225	1.495	1.573	.894
F16D	FTTM	1.462	1.298	1.069	1.194	1.495	1.573	.907
F16J79	FTMR	1.302	1.192	.835	.840	1.353	1.573	.889
F20	FTMR	1.355	1.357	.885	.993	1.193	2.750	.667
F20A	FTMR	1.355	1.334	.885	.993	1.193	2.750	.673
F4CD	FTMR	1.323	1.050	.921	1.009	1.411	.000	1.323
F4EF	FTMR	1.350	1.049	.844	.873	1.546	1.952	1.346
F4MOD	FTMR	1.350	1.087	1.185	1.111	2.077	1.952	1.366
F5A	FTMR	.940	1.025	.642	.634	.864	.855	.592
F5B	FTMR	.931	1.018	.642	.634	.864	.855	.594

F5E	FTMR	1.065	1.036	.756	.778	.899	.855	.644
F5F	FTMR	1.035	1.011	.626	.638	.899	.855	.654
F86F	FTMR	.837	.727	.676	.685	.325	.611	.884
G91Y	FTAT	.699	.960	.000	1.007	.649	.611	.695
HARMK80	FTMR	.856	1.311	1.067	1.111	.943	.764	.675
HAWK200	FTMR	.584	.963	1.184	1.140	.890	.917	.684
HAWK50T	FTTA	.625	.952	.000	.897	.423	.367	.681
HAWK60A	FTAT	.651	.932	1.074	1.087	.890	.367	.705
HAWK60T	FTTA	.651	.968	1.074	1.087	.660	.367	.681
HUNTER	FTMR	.798	.925	1.032	.973	.785	.611	.904
HUNTERT	F IM	.798	.915	1.071	.983	.785	.611	.912
IL28	BMAT	.392	.503	.000	1.449	1.001	1.986	1.927
JAGI04	FTAT	1.108	1.108	.000	1.165	1.171	.917	.843
JAGI11	FTAT	1.124	1.140	.000	1.165	1.171	.917	.843
JASTREB	FTAT	.378	.852	.000	.477	.817	1.237	.742
KFIRC2	FTMR	1.457	1.058	1.080	1.199	1.202	.855	.875
KFIRC7	FTMR	1.457	1.081	1.157	1.204	1.366	.855	.874
KFIRTC2	FTTM	1.457	1.052	.949	1.074	1.202	.855	.878
LAVI	FTMR	1.026	1.287	.798	.724	1.448	.855	.873
LIGHTNG	FTIN	1.432	1.076	.904	.000	.000	.733	1.125
L29	FTTA	.267	.782	.000	.359	.256	.611	.856
L39ZA	FTTC	.310	.774	.528	.553	.580	.458	.703
MB326K	FTAT	.447	.692	.000	.570	.886	.611	.721
MB326L	FTTA	.447	.692	.000	.570	.886	.611	.721
MB339A	FTTC	.501	.709	.657	.625	.886	.000	.770
MB339C	FTAT	.495	.720	.000	.761	.898	.855	.787
MB339K	FTAT	.495	.720	.000	.761	.898	.855	.787
MIG15BIS	FTMR	.651	.817	.600	.576	.325	.489	.767
MIG15UTI	FTTC	.629	.815	.469	.421	.000	.611	.735
MIG17F	FTMR	.619	.847	.628	.620	.309	.611	.829
MIG19C	FTMR	.837	1.104	.726	.652	.364	.611	.790
MIG21C	FTIN	.931	1.074	.700	.000	.000	.611	.681
MIG21F	FTMR	1.081	1.103	.716	.645	.548	.611	.680
MIG21JKL	FTMR	1.161	1.122	.700	.563	.548	.611	.681
MIG21R	FTRE	1.081	1.095	.000	.711	.000	.611	.683
MIG21UM	FTTM	1.155	1.109	.703	.637	.548	.611	.687
MIG23B	FTMR	1.459	1.056	.923	.955	.667	.611	1.270
MIG23E	FTMR	1.455	1.079	.923	.955	.667	.611	1.252
MIG23F	FTAT	1.206	.862	.000	.918	.667	.611	1.293
MIG23G	FTMR	1.468	1.067	.923	.955	.667	.611	1.262
MIG23UM	FTTC	1.369	.997	.814	.824	.667	.611	1.264
MIG25	FTIN	1.520	.897	1.044	.000	.000	.000	1.738
MIG25R	FTRE	1.554	.912	.000	1.019	.000	.000	1.676
MIG25U	FTTI	1.520	.897	1.022	.000	.000	.000	1.737
MIG27DJ	FTAT	1.090	.881	.000	.975	.882	1.528	1.299
MIG29	FTMR	1.582	1.361	.798	.887	1.096	.611	1.097
MIG31	FTIN	1.566	.997	1.263	.000	.000	1.100	1.697
MIRF1A	FTMR	1.400	1.006	1.205	1.062	.979	.825	.812
MIRF1B	FTTI	1.400	1.006	1.172	.000	.000	.825	.812
MIRF1C	FTMR	1.400	1.009	1.205	1.104	.979	.825	.810
MIRF1E	FTMR	1.734	.990	1.315	1.213	.979	.825	.824
MIRIIIC	FTIN	1.144	.962	1.037	.000	.000	.764	.858
MIRIIIE	FTMR	1.172	.965	1.292	1.150	.978	.764	.862
MIRIIIEI	FTMR	1.172	.965	1.292	1.150	1.216	.764	.863
MIR2000C	FTMR	1.563	1.217	.979	1.056	1.437	.764	.979
MIR2000R	FTRE	1.513	1.082	.000	1.252	.000	.611	.969
MIR2000T	FTTM	1.563	1.206	.957	1.035	1.437	.764	.985
MIR3NG	FTMR	1.169	.990	1.359	1.483	1.235	.764	.891
MIR4000	FTMR	1.467	1.334	1.519	1.252	1.838	.611	1.535
MIR5DD	FTTA	1.240	.925	.000	1.382	.943	.764	.898
MIR5DR	FTRE	1.240	.928	.000	1.521	.000	.764	.894
MIR5D1	FTIN	1.244	.960	1.238	.000	.000	.764	.866
MIR5D1E	FTIN	1.244	.958	1.238	.000	.000	.764	.867
MIR5D2	FTAT	1.240	.926	.000	1.521	.998	.764	.896
OV10D	MIAT	.213	.787	.000	.659	.750	3.055	.897
PRCA5	FTAT	.920	.846	.000	.759	.786	1.528	.881
PRCFT6	FTTM	.967	.935	.725	.641	.000	.611	.784
PRCF6	FTMR	.943	.962	.725	.693	.000	.611	.789

PRCF7	FTIN	.861	1.074	.700	.000	.000	.611	.681
PRCF7E	FTIN	.861	1.096	.700	.000	.000	.611	.680
RF4C	FTRE	1.318	1.053	.000	1.047	.000	.000	1.320
RF5E	FTRE	1.052	1.011	.000	.861	.000	.855	.654
SF260MW	MITA	.104	1.041	.000	.610	.503	.000	.502
SF260TP	MITA	.182	.796	.000	.610	.503	.000	.500
SUPETEN	FTAT	.842	.854	.000	1.016	.914	.764	.878
SU20	FTAT	1.318	.937	.000	.801	1.334	.428	1.289
SU22	FTAT	1.318	.930	.000	.935	1.431	.428	1.305
SU25	FTAT	.369	1.074	.000	.860	1.571	.611	1.338
SU27	FTMR	1.480	1.389	1.292	.913	1.290	.611	1.534
SU7BMKL	FTAT	.781	.934	.000	.559	.715	.428	.885
SU7U	FTTA	.784	.935	.000	.480	.715	.428	.884
TA4EH	FTTA	.612	.894	.000	1.169	.951	1.222	.761
TA4KU	FTTA	.595	.907	.000	.813	.951	1.222	.768
TORADV	FTIN	1.342	1.068	1.387	.000	.000	.611	1.355
TORIDS	FTAT	1.308	1.009	.000	1.554	1.935	.611	1.415
TU16AG	BMAT	.586	.523	.000	2.740	1.814	.611	4.187
TU22BD	BMAT	.877	.571	.000	2.924	2.342	.611	3.834

E.2 Target Acquisition Systems

Glossary

NFSTA = Target Acquisition Effectiveness Factor Score

NAME	CODE	NFSTA
AGAVE	RAMU	.742
AIDAII	RAGA	.360
AIRPASSI	RAAI	1.124
ANTILOPE	RAMU	1.432
APG63	RAMU	1.880
APG64	RAMU	2.021
APG65	RAMU	1.374
APG66	RAMU	1.176
APG67	RAMU	1.480
APG68	RAMU	1.445
APG69	RAMU	.910
APG70	RAMU	2.039
APN153V	RAGA	.596
APQ109	RAMU	.740
APQ120	RAMU	.777
APQ159	RAAI	.678
AWG9	RAAI	2.189
BLUEFOX	RAMU	1.094
CYRI	RAAI	.798
CYRII	RAMU	.894
CYRIV	RAAI	1.000
CYRIVM3	RAMU	1.094
CYRIV2	RAMU	1.094
ELM2001B	RAMU	.691
ELM2021B	RAMU	1.079
ELTAFIAR	RAGA	.762
FLANRAD	RAMU	1.982
FOXFIRE	RAAI	1.214
FOXHUNT	RAMU	2.042
FULRAD	RAMU	1.092
HIFIX	RAMU	.385
HILARKI	RAMU	.882
HILARKII	RAMU	1.050
HILARKX	RAAI	1.233
HOUNDRAD	RAAI	1.928
IRSTSB	IRAI	.491
IRSTSG	IRAI	.614
JAYBIRD	RAAI	.733
LASDES	LAGA	.349
LASRNG	LAGA	.316
RDA12	RAGA	.488
RDI	RAAI	1.355
RDM	RAMU	1.379
SCANFIX	RAAI	.450
SCANODD	RAAI	.458
SHRTHRN	RAGA	.762
SKYRNGR	RAAI	.568
SPNSCNA	RAAI	.484
SPNSCNB	RAAI	.484
TI-ATA	RAMU	1.160
TI-ATG	RAMU	1.355
VISUAL	VIMU	.275

E.3 Air-to-Air Missiles

Glossary

NFSPERF = Missile Performance Factor Score
NFSVUL = Vulnerability to Detection/Avoidance Factor Score

MSL	CODE	NFSPERF	NFSVUL
AA10A	AAMR	1.28	.86
AA2B	AAMI	.54	.75
AA2C	AAMR	.65	.68
AA2D	AAMI	.65	.68
AA6A	AAMR	1.23	2.21
AA6B	AAMI	1.14	2.21
AA7A	AAMR	1.33	1.49
AA7B	AAMI	1.25	1.47
AA8B	AAMI	.63	.65
AA9A	AAMR	1.68	1.46
AIM120A	AAMR	1.35	.86
AIM54	AAMR	3.21	1.76
AIM7C	AAMR	1.28	1.24
AIM7D	AAMR	1.28	1.27
AIM7E	AAMR	1.36	1.15
AIM7F	AAMR	1.94	1.17
AIM7M	AAMR	1.94	1.17
AIM9D	AAMI	.74	.72
AIM9E	AAMI	.49	.70
AIM9G	AAMI	.74	.71
AIM9H	AAMI	.74	.71
AIM9J	AAMI	.64	.63
AIM9L	AAMI	.86	.64
AIM9M	AAMI	.86	.64
AIM9PN	AAMI	.69	.63
ASPIDE	AAMR	1.48	1.34
FIRESTRK	AAMI	.81	1.11
KUKRI	AAMI	.39	.63
PIRANHA	AAMI	.55	.81
PYTHON3	AAMI	.65	.76
RBS70	AAMI	.28	.65
REDTOP	AAMI	.92	1.12
R530I	AAMI	.80	1.15
R530R	AAMR	.80	1.15
R550	AAMI	.74	.83
R550MK2	AAMI	.80	.76
SHAFRIR	AAMI	.57	.84
SKYFLASH	AAMR	1.30	1.32
STINGER	AAMI	.33	.68
SUP530D	AAMR	1.72	1.18
SUP530F	AAMR	1.35	1.21

E.4 Aerial Guns

Glossary

NFSRAT = Rate/Volume of Fire Factor Score
NFSEFF = Effectiveness Factor Score

GUN	CODE	NFSRAT	NFSEFF
ADENMK4	ACCI	.927	1.141
ADENMK5	ACCI	1.110	1.208
CB.50	ACCI	.834	.603
DEFA552A	ACCI	.857	1.158
DEFA553	ACCI	.857	1.326
DEFA554	ACCI	1.017	1.483
FN7.62	ACCI	.834	.603
GAU12U	ACCI	1.637	1.063
GAU13A	ACCE	1.301	1.567
GAU2BA	ACCE	1.361	.640
GAU8A	ACCI	1.610	1.219
GPU5A	ACCE	1.192	1.483
GSH23	ACCI	1.109	.732
HGS55	ACCE	.851	.589
HIS404	ACCI	.862	1.148
KCA30	ACCE	1.131	1.402
MAU27	ACCI	1.296	1.434
MKIIMOD5	ACCE	1.577	1.114
M16	ACCE	1.142	.580
M197	ACCE	1.395	1.057
M230	ACCE	.805	1.183
M28	ACCE	1.361	.642
M39	ACCI	1.232	1.057
M5	ACCE	.251	1.222
M61A1	ACCI	1.546	1.073
M621	ACCE	1.036	1.239
NR23	ACCI	.460	.744
NR23HS	ACCI	.481	.744
NR30	ACCI	.827	.921
NR30GAT	ACCI	1.541	.914
N37	ACCI	.389	.973
N37D	ACCI	.675	.973
UBK	ACCE	.899	.803
US12.7	ACCI	.899	.773
XM188E30	ACCE	1.021	1.204
XM27E1	ACCE	1.402	.603
XM8	ACCE	.278	1.383

Appendix F

COMBAT POTENTIAL SCORES MIDEAST AIR WEAPON SYSTEMS

F.1 Air Defense Mission

Glossary

AWSADX = Air Weapon System Potential - Air Defense
AFADX = Air Frame Potential - Air Defense
TAADX = Target Acquisition Potential - Air Defense
PLADX = Payload Potential - Air Defense
VADX = Vulnerability to Detection and Engagement - Air Defense

ACFT	PRODCC	ROLE	AWSADX	AFADX	TAADX	PLADX	VADX
FA18L	US	FTMR	2.523	1.505	1.262	2.440	.672
F14AC	US	FTIN	2.459	1.439	1.674	2.991	.820
F15A	US	FTMR	3.746	1.464	1.706	5.264	.732
F15B	US	FTTM	3.731	1.441	1.723	5.264	.735
F15C	US	FTMR	4.058	1.543	2.007	5.264	.711
F15CFP	US	FTMR	3.985	1.510	2.007	5.953	.776
F15D	US	FTTM	4.034	1.521	2.007	5.264	.714
F15E	US	FTMR	5.242	1.582	2.042	7.762	.703
F16A	US	FTMR	1.972	1.502	.916	1.287	.606
F16B	US	FTTM	1.972	1.483	.932	1.287	.607
F16C	US	FTMR	2.715	1.458	1.452	2.213	.622
F16CSC	US	FTMR	1.541	1.463	.916	.991	.709
F16D	US	FTTM	2.701	1.437	1.468	2.213	.626
F16J79	US	FTMR	1.357	1.252	.916	.991	.761
F20	US	FTMR	1.933	1.349	1.485	1.065	.681
F20A	US	FTMR	2.843	1.342	1.485	2.287	.596
F4CD	US	FTMR	.978	1.181	.388	.878	.779
F4EF	US	FTMR	1.579	1.226	.451	2.259	.778
F4MOD	US	FTMR	2.187	1.358	1.279	2.535	.773
F5A	US	FTMR	.470	.841	.055	.525	.895
F5B	US	FTMR	.473	.835	.071	.525	.901
F5E	US	FTMR	.855	1.071	.386	.510	.721
F5F	US	FTMR	.800	1.004	.402	.469	.739
F86F	US	FTMR	.208	.680	.055	.083	1.148
HARMK80	UK	FTMR	.923	1.125	.055	1.170	.759
HAWK200	UK	FTMR	.693	.992	.656	.646	1.079
HUNTER	UK	FTMR	.250	.783	.055	.103	1.097
HUNTERT	UK	FTTM	.256	.787	.071	.103	1.101
KFIRC2	IS	FTMR	1.116	1.294	.434	.654	.666
KFIRC7	IS	FTMR	1.646	1.390	1.097	.800	.661
KFIRTC2	IS	FTTM	.748	1.247	.071	.390	.668
LAVI	IS	FTMR	1.402	1.156	1.097	.800	.729
LIGHTNG	UK	FTIN	.771	1.071	.672	.366	.894
MIG15BIS	UR	FTMR	.177	.615	.055	.065	1.212
MIG17F	UR	FTMR	.242	.615	.251	.083	1.242
MIG19C	UR	FTMR	.424	.798	.247	.269	.963
MIG21C	UR	FTIN	.635	.824	.291	.721	.904
MIG21F	UR	FTMR	.706	.898	.291	.722	.842
MIG21JKL	UR	FTMR	.887	1.016	.412	.868	.815

MIG21UM	UR	FTTM	.744	.929	.308	.722	.820
MIG23B	UR	FTMR	1.103	1.187	.486	1.083	.786
MIG23E	UR	FTMR	.889	1.192	.412	.868	.868
MIG23G	UR	FTMR	1.258	1.194	.695	1.168	.780
MIG25	UR	FTIN	.879	1.201	.648	.634	.908
MIG25U	UR	FTTI	.877	1.195	.648	.634	.908
MIG29	UR	FTMR	2.554	1.416	.854	2.808	.633
MIG31	UR	FTIN	2.370	1.386	1.624	2.867	.820
MIRF1A	FR	FTMR	.884	1.358	.209	.556	.722
MIRF1B	FR	FTTI	.889	1.346	.225	.556	.722
MIRF1C	FR	FTMR	1.457	1.359	.856	1.029	.721
MIRF1E	FR	FTMR	1.776	1.531	1.112	1.029	.677
MIRIIIC	FR	FTIN	.793	1.060	.491	.674	.892
MIRIIIE	FR	FTMR	.902	1.147	.604	.737	.884
MIRIIIEI	FR	FTMR	1.086	1.222	.604	.723	.749
MIR2000C	FR	FTMR	2.522	1.421	1.387	2.058	.636
MIR2000T	FR	FTTM	2.515	1.409	1.404	2.058	.639
MIR3NG	FR	FTMR	1.480	1.230	1.112	1.205	.794
MIR4000	FR	FTMR	2.104	1.609	1.146	2.046	.739
MIR5D1	FR	FTIN	.843	1.160	.435	.737	.868
MIR5D1E	FR	FTIN	1.624	1.159	1.112	2.032	.869
PRCFT6	CH	FTTM	.365	.803	.264	.091	.990
PRCF6	CH	FTMR	.413	.801	.247	.273	.993
PRCF7	CH	FTIN	.626	.836	.291	.751	.936
PRCF7E	EG	FTIN	.695	.842	.291	.943	.931
SU27	UR	FTMR	3.148	1.474	1.796	3.692	.729
TORADV	UK	FTIN	2.360	1.418	1.566	2.902	.822

F.2 Fighter Mission

Glossary

AWSFTR = Air Weapon System Potential - Fighter
AFFTR = Air Frame Potential - Fighter
TAFTR = Target Acquisition Potential - Fighter
PLFTR = Payload Potential - Fighter
VFTR = Vulnerability to Detection and Engagement - Fighter

ACFT	PRODCC	ROLE	AWSFTR	AFFTR	TAFTR	PLFTR	VFTR
FA18L	US	FTMR	2.185	1.508	1.097	2.026	.692
F14AC	US	FTIN	2.045	1.427	1.454	2.426	.849
F15A	US	FTMR	2.800	1.423	1.469	3.754	.764
F15B	US	FTTM	2.789	1.401	1.495	3.754	.768
F15C	US	FTMR	3.065	1.520	1.720	3.754	.739
F15CFP	US	FTMR	3.005	1.503	1.720	4.186	.795
F15D	US	FTTM	3.041	1.498	1.720	3.754	.742
F15E	US	FTMR	3.934	1.576	1.762	5.612	.726
F16A	US	FTMR	2.153	1.532	.808	1.726	.614
F16B	US	FTTM	2.158	1.513	.834	1.726	.614
F16C	US	FTMR	2.392	1.476	1.256	1.877	.633
F16CSC	US	FTMR	1.734	1.483	.808	1.354	.689
F16D	US	FTTM	2.379	1.454	1.282	1.877	.638
F16J79	US	FTMR	1.525	1.276	.808	1.354	.739
F20	US	FTMR	2.125	1.393	1.284	1.478	.649
F20A	US	FTMR	2.576	1.382	1.284	2.001	.594
F4CD	US	FTMR	.968	1.147	.379	.875	.807
F4EF	US	FTMR	1.420	1.220	.431	1.954	.809
F4MOD	US	FTMR	1.880	1.350	1.124	2.156	.802
F5A	US	FTMR	.579	.861	.088	.720	.920
F5B	US	FTMR	.584	.856	.114	.720	.926
F5E	US	FTMR	.993	1.099	.364	.701	.713
F5F	US	FTMR	.924	1.035	.391	.632	.731
F86F	US	FTMR	.258	.673	.088	.141	1.149
HARMK80	UK	FTMR	1.242	1.221	.088	1.528	.720
HAWK200	UK	FTMR	.859	1.055	.590	.868	.962
HUNTER	UK	FTMR	.326	.804	.088	.175	1.076
HUNTERT	UK	FTTM	.334	.806	.114	.175	1.081
KFIRC2	IS	FTMR	1.198	1.242	.405	.878	.687
KFIRC7	IS	FTMR	1.657	1.370	.959	1.070	.681
KFIRTC2	IS	FTTM	.871	1.197	.114	.546	.690
LAVI	IS	FTMR	1.516	1.230	.959	1.070	.714
LIGHTNG	UK	FTIN	.781	1.039	.604	.509	.920
MIG15BIS	UR	FTMR	.238	.644	.088	.111	1.170
MIG17F	UR	FTMR	.294	.652	.252	.140	1.193
MIG19C	UR	FTMR	.564	.844	.249	.376	.858
MIG21C	UR	FTIN	.757	.854	.286	.748	.808
MIG21F	UR	FTMR	.834	.914	.286	.750	.758
MIG21JKL	UR	FTMR	1.038	1.020	.387	.946	.736
MIG21UM	UR	FTTM	.876	.937	.312	.750	.742
MIG23B	UR	FTMR	1.054	1.141	.448	.912	.774
MIG23E	UR	FTMR	.979	1.150	.387	.946	.824
MIG23G	UR	FTMR	1.192	1.148	.623	1.020	.768
MIG25	UR	FTIN	.796	1.124	.583	.494	.923
MIG25U	UR	FTTI	.794	1.118	.583	.494	.923
MIG29	UR	FTMR	2.057	1.436	.756	1.968	.653
MIG31	UR	FTIN	1.803	1.308	1.412	2.067	.873
MIRF1A	FR	FTMR	1.069	1.330	.217	.753	.697
MIRF1B	FR	FTTI	1.078	1.319	.243	.753	.697
MIRF1C	FR	FTMR	1.512	1.331	.758	1.105	.695
MIRF1E	FR	FTMR	1.760	1.457	.972	1.105	.666
MIRIIIC	FR	FTIN	.895	1.037	.453	.762	.825
MIRIIIE	FR	FTMR	1.004	1.115	.547	.841	.820

MIRIIIEI	FR	FTMR	1.105	1.185	.547	.823	.760
MIR2000C	FR	FTMR	2.130	1.414	1.202	1.631	.657
MIR2000T	FR	FTTM	2.127	1.401	1.228	1.631	.661
MIR3NG	FR	FTMR	1.531	1.228	.972	1.322	.759
MIR4000	FR	FTMR	1.806	1.621	1.000	1.611	.768
MIR5D1	FR	FTIN	.955	1.120	.406	.841	.808
MIR5D1E	FR	FTIN	1.489	1.120	.972	1.586	.809
PRCFT6	CH	FTTM	.422	.810	.275	.154	.984
PRCF6	CH	FTMR	.484	.814	.249	.382	.983
PRCF7	CH	FTIN	.761	.871	.286	.799	.832
PRCF7E	EG	FTIN	.857	.881	.286	1.040	.826
SU27	UR	FTMR	2.260	1.460	1.543	2.194	.757
TORADV	UK	FTIN	2.130	1.403	1.364	2.501	.806

F.3 Interdiction Mission

Glossary

AWSINT = Air Weapon System Potential - Interdiction
AFINT = Air Frame Potential - Interdiction
TAINT = Target Acquisition Potential - Interdiction
PLINT = Payload Potential - Interdiction
VINT = Vulnerability to Detection and Engagement - Interdiction

ACFT	PRODCC	ROLE	AWSINT	AFINT	TAINT	PLINT	VINT
ALPHAMS2	FR	FTAT	.538	.784	.222	.789	1.074
AMX	IT	FTAT	.895	.922	.430	1.208	.942
A10A	US	FTAT	.670	.737	.190	2.047	1.501
A37B	US	FTAT	.282	.501	.139	.603	1.434
A4H	US	FTAT	.753	.922	.274	1.172	1.025
A4KU	US	FTAT	.565	.702	.274	.961	1.126
A4N	US	FTAT	.855	.800	.274	1.470	.990
A7E	US	FTAT	1.061	1.012	.190	1.908	.971
A7P	US	FTAT	.730	.881	.107	1.569	1.155
BAC167	UK	FTAT	.204	.503	.139	.390	1.605
C101BB	SP	FTAT	.270	.575	.139	.634	1.613
C101CC	SP	FTAT	.288	.609	.139	.634	1.541
C101DD	SP	FTTA	.396	.609	.139	1.095	1.541
FA18L	US	FTMR	2.272	1.374	.882	2.066	.634
F104GCF	US	FTAT	.785	1.014	.107	.948	.834
F15A	US	FTMR	1.848	1.331	1.055	1.480	.694
F15B	US	FTTM	1.847	1.306	1.087	1.480	.697
F15C	US	FTMR	2.024	1.414	1.227	1.480	.676
F15CFP	US	FTMR	1.951	1.388	1.227	1.694	.737
F15D	US	FTTM	2.008	1.395	1.227	1.480	.679
F15E	US	FTMR	2.760	1.438	1.379	2.637	.669
F16A	US	FTMR	2.248	1.366	.683	1.837	.571
F16B	US	FTTM	2.261	1.352	.716	1.837	.571
F16C	US	FTMR	2.374	1.343	.991	1.837	.586
F16CSC	US	FTMR	1.667	1.347	.601	1.496	.675
F16D	US	FTTM	2.374	1.329	1.023	1.837	.589
F16J79	US	FTMR	1.415	1.126	.601	1.379	.723
F20	US	FTMR	1.790	1.245	.928	1.327	.646
F20A	US	FTMR	2.068	1.238	.928	1.327	.559
F4CD	US	FTMR	1.078	1.087	.321	1.056	.735
F4EF	US	FTMR	1.536	1.110	.466	1.822	.734
F4MOD	US	FTMR	2.150	1.195	.941	2.498	.730
F5A	US	FTMR	.526	.754	.107	.628	.893
F5B	US	FTMR	.534	.749	.139	.628	.899
F5E	US	FTMR	.990	.968	.297	.820	.673
F5F	US	FTMR	.994	.906	.438	.776	.690
F86F	US	FTMR	.263	.613	.107	.258	1.132
G91Y	IT	FTAT	.469	.722	.244	.644	1.103
HARMK80	UK	FTMR	1.070	1.020	.216	1.131	.713
HAWK200	UK	FTMR	.808	.874	.534	1.072	1.014
HAWK50T	UK	FTTA	.312	.670	.139	.360	1.161
HAWK60A	UK	FTAT	.446	.762	.190	.655	1.148
HAWK60T	UK	FTTA	.381	.773	.107	.510	1.135
HUNTER	UK	FTMR	.380	.694	.107	.518	1.089
HUNTERT	UK	FTTM	.389	.693	.139	.518	1.093
IL28	UR	BMAT	.236	.578	.139	.637	1.854
JAGI04	UK	FTAT	1.001	1.126	.190	1.118	.776
JAGI11	UK	FTAT	1.020	1.142	.190	1.118	.765
JASTREB	YU	FTAT	.230	.463	.107	.544	1.567
KFIRC2	IS	FTMR	1.519	1.199	.325	1.400	.624
KFIRC7	IS	FTMR	1.898	1.262	.705	1.593	.619
KFIRTC2	IS	FTTM	1.387	1.158	.139	1.400	.626
LAVI	IS	FTMR	1.662	1.015	.705	1.679	.686

L29	CZ	FTTA	.098	.360	.139	.133	1.998
MB326K	IT	FTAT	.244	.438	.107	.568	1.482
MB326L	IT	FTTA	.226	.438	.139	.459	1.482
MB339C	IT	FTAT	.443	.610	.190	.908	1.268
MB339K	IT	FTAT	.325	.532	.107	.635	1.268
MIG15BIS	UR	FTMR	.229	.549	.107	.239	1.195
MIG17F	UR	FTMR	.261	.551	.219	.249	1.225
MIG19C	UR	FTMR	.408	.706	.218	.283	.915
MIG21F	UR	FTMR	.539	.797	.243	.350	.800
MIG21JKL	UR	FTMR	.643	.878	.312	.403	.774
MIG21UM	UR	FTTM	.579	.825	.275	.350	.779
MIG23B	UR	FTMR	.878	1.075	.354	.647	.745
MIG23E	UR	FTMR	.749	1.079	.312	.597	.830
MIG23F	UR	FTAT	.566	.918	.190	.597	.941
MIG23G	UR	FTMR	.947	1.081	.475	.647	.740
MIG27DJ	UR	FTAT	.760	.894	.190	.885	.829
MIG29	UR	FTMR	1.759	1.300	.648	1.284	.599
MIRF1A	FR	FTMR	1.077	1.174	.278	.866	.679
MIRF1C	FR	FTMR	1.287	1.188	.649	.866	.678
MIRF1E	FR	FTMR	1.521	1.342	.796	.866	.637
MIRIIIE	FR	FTMR	.903	.992	.422	.926	.839
MIRIIIEI	FR	FTMR	1.346	1.051	.422	1.399	.701
MIR2000C	FR	FTMR	2.190	1.300	.981	1.660	.599
MIR2000T	FR	FTTM	1.999	1.290	1.013	1.333	.602
MIR3NG	FR	FTMR	1.357	1.134	.714	1.231	.747
MIR4000	FR	FTMR	2.026	1.360	.842	2.069	.703
MIR5DD	FR	FTTA	.750	1.067	.228	.716	.840
MIR5D2	FR	FTAT	.903	1.103	.325	.942	.839
PRCA5	CH	FTAT	.492	.726	.107	.654	.958
PRCFT6	CH	FTTM	.323	.709	.250	.098	.987
PRCF6	CH	FTMR	.312	.715	.218	.098	.990
SUPETEN	FR	FTAT	.745	.856	.325	.882	.898
SU20	UR	FTAT	.992	.999	.202	1.127	.756
SU22	UR	FTAT	1.216	1.031	.311	1.478	.761
SU25	UR	FTAT	.493	.596	.190	1.425	1.510
SU27	UR	FTMR	1.831	1.205	1.106	1.487	.693
SU7BMKL	UR	FTAT	.425	.626	.202	.452	.955
SU7U	UR	FTTA	.399	.615	.139	.452	.952
TA4EH	US	FTTA	.602	.766	.306	.971	1.112
TA4KU	US	FTTA	.561	.671	.306	.937	1.126
TORIDS	UK	FTAT	1.897	1.291	.874	2.160	.764
TU16AG	UR	BMAT	.441	.781	.353	1.354	1.878
TU22BD	UR	BMAT	.637	.933	.353	1.728	1.577

F.4 Close Air Support Mission (CAS)

Glossary

AWSCAS = Air Weapon System Potential - CAS
AFCAS = Air Frame Potential - CAS
TACAS = Target Acquisition Potential - CAS
PLCAS = Payload Potential - CAS
VCAS = Vulnerability to Detection and Engagement - CAS

ACFT	PRODCC	ROLE	AWSCAS	AFCAS	TACAS	PLCAS	VCAS
ALPHAMS1	FR	FTTC	.531	.827	.204	.432	.868
ALPHAMS2	FR	FTAT	.805	.900	.299	.776	.804
AMX	IT	FTAT	1.250	1.033	.341	1.268	.711
A10A	US	FTAT	1.302	.910	.252	2.661	1.052
A37B	US	FTAT	.484	.574	.204	.661	.997
A4H	US	FTAT	1.037	1.077	.219	1.139	.780
A4KU	US	FTAT	.810	.788	.219	1.031	.851
A4N	US	FTAT	1.121	.908	.219	1.361	.758
A7E	US	FTAT	1.743	1.160	.252	2.351	.755
A7P	US	FTAT	1.325	1.016	.157	2.141	.877
BAC167	UK	FTAT	.349	.584	.204	.446	1.149
CM170	FR	FTTC	.314	.553	.204	.419	1.215
CM170I	IS	FTTC	.314	.553	.204	.419	1.215
C101BB	SP	FTAT	.473	.693	.204	.712	1.129
C101CC	SP	FTAT	.501	.733	.204	.712	1.087
C101DD	SP	FTTA	.608	.733	.204	1.009	1.087
FA18L	US	FTMR	2.593	1.445	.509	2.046	.525
F104GCF	US	FTAT	1.279	.977	.157	1.442	.688
F15A	US	FTMR	2.247	1.367	.509	1.998	.588
F15B	US	FTTM	2.247	1.333	.556	1.998	.591
F15C	US	FTMR	2.410	1.482	.573	1.998	.570
F15CFP	US	FTMR	2.362	1.518	.573	2.146	.610
F15D	US	FTTM	2.387	1.456	.573	1.998	.573
F15E	US	FTMR	3.115	1.529	.749	2.764	.560
F16A	US	FTMR	2.721	1.441	.435	1.842	.461
F16B	US	FTTM	2.743	1.423	.482	1.842	.462
F16C	US	FTMR	2.699	1.408	.549	1.842	.476
F16CSC	US	FTMR	2.103	1.414	.340	1.632	.539
F16D	US	FTTM	2.702	1.388	.596	1.842	.480
F16J79	US	FTMR	1.802	1.161	.340	1.551	.574
F20	US	FTMR	2.329	1.310	.462	1.691	.502
F20A	US	FTMR	2.651	1.300	.462	1.691	.440
F4CD	US	FTMR	1.094	1.091	.271	.731	.614
F4EF	US	FTMR	1.944	1.120	.410	1.936	.616
F4MOD	US	FTMR	2.401	1.235	.587	2.401	.612
F5A	US	FTMR	.832	.760	.157	.773	.673
F5B	US	FTMR	.849	.756	.204	.773	.677
F5E	US	FTMR	1.342	1.015	.227	.898	.523
F5F	US	FTMR	1.288	.940	.400	.769	.535
F86F	US	FTMR	.397	.592	.157	.381	.911
G91Y	IT	FTAT	.655	.786	.208	.691	.844
HARMK80	UK	FTMR	1.578	1.157	.282	1.080	.526
HAWK200	UK	FTMR	1.065	1.029	.380	1.032	.760
HAWK50T	UK	FTTA	.513	.738	.204	.461	.875
HAWK60A	UK	FTAT	.664	.859	.252	.671	.873
HAWK60T	UK	FTTA	.595	.875	.157	.568	.859
HUNTER	UK	FTMR	.567	.718	.157	.614	.859
HUNTERT	UK	FTTM	.582	.717	.204	.614	.863
JAGI04	UK	FTAT	1.405	1.216	.252	1.120	.605
JAGI11	UK	FTAT	1.433	1.234	.252	1.120	.597
JASTREB	YU	FTAT	.405	.533	.157	.652	1.114
KFIRC2	IS	FTMR	1.740	1.199	.238	1.256	.514
KFIRC7	IS	FTMR	2.035	1.292	.379	1.432	.509

KFIRTC2	IS	FTTM	1.683	1.146	.204	1.256	.516
LAVI	IS	FTMR	1.901	1.099	.379	1.491	.530
L29	CZ	FTTA	.162	.427	.204	.094	1.369
L39ZA	CZ	FTTC	.310	.511	.204	.457	1.243
MB326K	IT	FTAT	.395	.474	.157	.643	1.094
MB326L	IT	FTTA	.296	.474	.204	.324	1.094
MB339A	IT	FTTC	.385	.546	.204	.349	.916
MB339C	IT	FTAT	.690	.690	.252	.928	.919
MB339K	IT	FTAT	.549	.586	.157	.751	.919
MIG15BIS	UR	FTMR	.362	.565	.157	.325	.919
MIG15UTI	UR	FTTC	.321	.528	.204	.218	.924
MIG17F	UR	FTMR	.395	.579	.198	.374	.936
MIG19C	UR	FTMR	.590	.729	.198	.409	.717
MIG21F	UR	FTMR	.673	.778	.207	.395	.646
MIG21JKL	UR	FTMR	.806	.862	.233	.503	.630
MIG21UM	UR	FTTM	.717	.795	.254	.395	.634
MIG23B	UR	FTMR	.953	1.034	.249	.669	.655
MIG23E	UR	FTMR	.851	1.042	.233	.632	.714
MIG23F	UR	FTAT	.715	.894	.252	.632	.802
MIG23G	UR	FTMR	.986	1.040	.293	.669	.651
MIG23UM	UR	FTTC	.825	.948	.280	.669	.742
MIG27DJ	UR	FTAT	1.034	.897	.252	.968	.682
MIG29	UR	FTMR	1.916	1.316	.422	1.164	.497
MIRF1A	FR	FTMR	1.314	1.188	.284	.898	.585
MIRF1C	FR	FTMR	1.405	1.207	.422	.898	.584
MIRF1E	FR	FTMR	1.536	1.313	.477	.898	.564
MIRIIIE	FR	FTMR	1.035	1.006	.274	.912	.696
MIRIIIEI	FR	FTMR	1.526	1.084	.274	1.219	.564
MIR2000C	FR	FTMR	2.251	1.316	.566	1.461	.497
MIR2000T	FR	FTTM	2.105	1.302	.613	1.259	.499
MIR3NG	FR	FTMR	1.420	1.204	.382	1.129	.630
MIR4000	FR	FTMR	2.068	1.430	.515	1.709	.594
MIR5DD	FR	FTTA	.959	1.084	.237	.775	.705
MIR5D2	FR	FTAT	1.061	1.132	.238	.924	.704
OV10D	US	MIAT	.596	.524	.329	1.517	1.419
PRCA5	CH	FTAT	.728	.722	.157	.815	.778
PRCFT6	CH	FTTM	.482	.690	.245	.287	.791
PRCF6	CH	FTMR	.468	.706	.198	.287	.790
SF260MW	IT	MITA	.122	.542	.204	.184	2.349
SF260TP	IT	MITA	.164	.466	.204	.184	1.627
SUPETEN	FR	FTAT	.935	.918	.238	.903	.728
SU20	UR	FTAT	1.103	.978	.192	.951	.635
SU22	UR	FTAT	1.319	1.020	.317	1.179	.639
SU25	UR	FTAT	.744	.721	.252	1.284	1.050
SU27	UR	FTMR	1.734	1.213	.528	1.303	.585
SU7BMKL	UR	FTAT	.596	.634	.192	.500	.724
SU7U	UR	FTTA	.597	.618	.204	.500	.722
TA4EH	US	FTTA	.850	.868	.266	1.009	.844
TA4KU	US	FTTA	.799	.747	.266	.994	.851
TORIDS	UK	FTAT	1.935	1.372	.562	1.746	.642

Appendix G

MIDDLE EASTERN AIR COMBAT POTENTIAL 1984-1990

NOTE: Depicted in Air Combat Potential Units undepreciated for maintenance force quality.

YEAR	INVENTORY	AIR DEFENSE	FIGHTER	INTERDICTION	CAS
Algeria					
1984	294	59.28	46.89	17.87	68.70
1985	295	58.12	46.18	18.43	68.12
1986	285	58.12	46.18	17.47	64.83
1987	275	58.12	46.18	16.80	62.97
1988	266	69.17	50.88	15.85	59.68
1989	259	86.69	58.17	14.90	56.38
1990	239	97.25	62.47	12.99	49.80
Bahrain					
1984	6	.97	.77	.58	1.86
1985	8	1.29	1.03	.77	2.49
1986	12	1.93	1.53	1.16	3.72
1987	12	1.93	1.53	1.16	3.72
1988	12	1.93	1.53	1.16	3.72
1989	12	1.93	1.53	1.16	3.72
1990	12	1.93	1.53	1.16	3.72
Egypt					
1984	441	165.00	130.90	31.66	98.93
1985	450	158.57	125.61	35.66	111.72
1986	441	166.56	129.34	34.16	107.05
1987	437	189.81	140.44	31.15	97.86
1988	419	202.51	145.21	36.58	107.27
1989	399	194.81	138.86	43.00	120.75
1990	399	194.81	138.86	43.00	120.75
Ethiopia					
1984	138	.00	.00	12.31	37.72
1985	153	.00	.00	13.01	39.94
1986	148	.00	.00	12.06	36.73
1987	148	.00	.00	12.06	36.73
1988	150	.00	.00	12.59	38.62
1989	150	.00	.00	12.49	38.95
1990	150	.00	.00	12.40	39.29
Iran					
1984	110	97.55	59.59	62.16	156.85
1985	94	73.23	44.52	49.98	127.16
1986	76	58.68	35.72	39.97	102.35
1987	56	40.85	24.94	28.43	73.08
1988	47	25.55	15.63	25.80	66.35
1989	47	25.55	15.63	25.80	66.35
1990	47	25.55	15.63	25.80	66.35

YEAR	INVENTORY	AIR DEFENSE	FIGHTER	INTERDICTION	CAS
Iraq					
1984	457	222.64	182.70	32.33	87.85
1985	508	256.49	209.77	40.73	110.89
1986	541	240.82	195.07	55.96	152.74
1987	563	249.18	198.98	61.71	169.59
1988	556	247.39	190.79	64.85	177.67
1989	556	261.72	196.01	64.85	177.67
1990	556	276.05	201.23	64.85	177.67
Israel					
1984	491	427.70	280.31	257.87	662.36
1985	509	452.25	297.86	272.47	695.39
1986	527	534.31	346.97	289.89	716.37
1987	541	612.34	397.53	316.77	770.82
1988	544	658.01	428.10	331.95	797.91
1989	523	669.14	434.92	328.01	780.51
1990	499	646.84	419.70	316.10	746.92
Jordan					
1984	125	41.81	29.28	47.87	146.15
1985	126	46.34	32.53	46.58	141.97
1986	126	46.34	32.53	46.58	141.97
1987	132	46.34	32.53	46.58	152.00
1988	130	46.34	32.53	43.73	152.29
1989	134	46.34	32.53	44.45	158.12
1990	134	46.34	32.53	44.45	158.12
Kuwait					
1984	64	7.22	5.15	3.39	12.14
1985	80	12.87	9.09	2.98	17.76
1986	89	16.37	11.55	2.98	17.76
1987	89	16.37	11.55	2.98	17.76
1988	89	16.37	11.55	2.98	17.76
1989	89	16.37	11.55	2.98	17.76
1990	89	16.37	11.55	2.98	17.76
Lebanon					
1984	5	.00	.00	.00	.00
1985	3	.00	.00	.00	.00
1986	0	.00	.00	.00	.00
1987	0	.00	.00	.00	.00
1988	0	.00	.00	.00	.00
1989	0	.00	.00	.00	.00
1990	0	.00	.00	.00	.00

YEAR	INVENTORY	AIR DEFENSE	FIGHTER	INTERDICTION	CAS
Libya					
1984	460	17.70	12.51	8.82	29.65
1985	505	19.66	13.91	9.11	30.60
1986	528	21.75	15.18	9.11	30.60
1987	527	22.22	15.29	9.11	30.60
1988	530	25.86	17.22	8.99	30.49
1989	530	28.95	18.64	8.99	30.49
1990	518	28.83	18.31	8.99	30.49
Morocco					
1984	94	.00	.00	34.85	115.83
1985	93	.00	.00	34.25	114.47
1986	93	.00	.00	34.25	114.47
1987	93	.00	.00	34.25	114.47
1988	93	.00	.00	34.25	114.47
1989	93	.00	.00	34.25	114.47
1990	93	.00	.00	34.25	114.47
Oman					
1984	52	.00	.00	9.60	41.91
1985	52	.00	.00	9.60	41.91
1986	50	.00	.00	9.36	41.06
1987	46	7.13	4.45	8.48	37.89
1988	50	14.26	8.90	8.48	37.89
1989	50	14.26	8.90	8.48	37.89
1990	50	14.26	8.90	8.48	37.89
Qatar					
1984	15	.00	.00	1.14	3.75
1985	21	.00	.00	1.84	5.82
1986	24	.00	.00	2.04	6.35
1987	22	.00	.00	1.99	6.14
1988	22	.00	.00	1.99	6.14
1989	22	.00	.00	1.99	6.14
1990	22	.00	.00	1.99	6.14
Saudi Arabia					
1984	183	183.85	97.20	52.11	156.09
1985	192	209.79	110.72	52.11	156.09
1986	198	212.17	111.87	55.27	165.45
1987	202	204.45	106.49	68.98	198.08
1988	214	226.56	120.31	71.53	199.05
1989	220	248.66	134.13	70.29	190.36
1990	220	248.66	134.13	70.29	190.36

YEAR	INVENTORY	AIR DEFENSE	FIGHTER	INTERDICTION	CAS
Somalia					
1984	64	3.45	2.79	2.20	8.35
1985	64	3.45	2.79	2.20	8.35
1986	64	3.45	2.79	2.20	8.35
1987	64	3.45	2.79	2.20	8.35
1988	64	3.45	2.79	2.20	8.35
1989	64	3.45	2.79	2.20	8.35
1990	64	3.45	2.79	2.20	8.35
Sudan					
1984	35	4.60	3.84	3.74	12.51
1985	35	4.60	3.84	3.74	12.51
1986	46	5.86	4.88	4.90	18.13
1987	52	7.11	5.91	5.61	21.83
1988	49	7.11	5.91	5.29	20.81
1989	46	7.11	5.91	4.96	19.79
1990	46	7.11	5.91	4.96	19.79
Syria					
1984	508	326.11	264.16	75.27	210.57
1985	554	380.97	302.42	76.82	214.16
1986	539	385.76	305.47	71.75	198.87
1987	541	418.42	320.09	70.66	195.83
1988	528	439.14	326.21	68.55	190.29
1989	498	434.23	310.59	69.40	192.93
1990	480	544.74	347.32	65.60	181.34
Tunisia					
1984	8	.00	.00	.00	5.65
1985	20	.00	.00	5.20	21.06
1986	22	.00	.00	6.07	23.56
1987	22	.00	.00	6.07	23.56
1988	22	.00	.00	6.07	23.56
1989	22	.00	.00	6.07	23.56
1990	22	.00	.00	6.07	23.56
United Arab Emirates					
1984	40	6.25	4.80	.42	5.89
1985	39	6.00	4.61	.42	5.89
1986	53	8.92	6.29	1.62	10.31
1987	59	17.61	10.71	2.42	13.17
1988	67	26.30	15.14	3.21	16.03
1989	75	34.10	19.63	3.21	16.03
1990	75	34.10	19.63	3.21	16.03

YEAR	INVENTORY	AIR DEFENSE	FIGHTER	INTERDICTION	CAS
North Yemen					
1984	75	3.53	2.82	2.74	8.33
1985	73	3.39	2.71	2.66	8.05
1986	73	3.39	2.71	2.66	8.05
1987	73	3.39	2.71	2.66	8.05
1988	73	3.39	2.71	2.66	8.05
1989	73	3.39	2.71	2.66	8.05
1990	73	3.39	2.71	2.66	8.05
South Yemen					
1984	104	13.41	10.91	6.03	16.64
1985	104	13.41	10.91	6.03	16.64
1986	104	13.41	10.91	6.03	16.64
1987	104	12.38	9.93	6.03	16.64
1988	104	19.38	13.01	5.67	16.27
1989	98	25.78	15.58	5.67	16.27
1990	110	35.03	20.65	5.67	16.27

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13. Department of State — 2
Arms Control and Disarmament Agency
320 - 21st Street, N.W.
Washington, D.C. 20451
ATTN: Mr. E. Finegold

14. Defense Intelligence Agency — 2
Directorate of Estimates/MCS
Rm. C6-930
Defense Intelligence Analysis Center
Washington, D.C. 20305
ATTN: Mr. J. P. Longo

15. Defense Intelligence Agency — 15
Directorate for OJCS Intelligence Support
Rm. 1E935
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ATTN: Lt. Col. C. L. Christon

END

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